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TABLES OF DIELECTRIC MATERIALS, VOL V



A. VON HIPPEL W. B. WESTPHAL

LABORATORY FOR INSULATION RESEARCH MASSACHUSETTS INSTITUTE OF TECHNOLOGY CAMBRIDGE MA

APRIL 1957

FINAL REPORT

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This report is a co	ompilation of dielectr	ic materials prope	rties. It was
originally published	ed in April 1957, by t	the Laboratory for	Insulation Research,
Massachusetts Insti	itute of Technology.	The report include	s (1) dielectric
constant and loss t	tangent data as a func	ction of temperatur	e and frequency,
(2) low field strem	ngth data at fixed tem	nperatures as a fun	ction of frequency,
hysteresis loops ar	nd saturation magnetiz	ation for ferromag	netic dielectrics
and (3) attenuation	n characteristics of f lastic mixtures and ma	errites, conducting	tures
plastics, carbon-pl	lastic mixtures and ma	ignetic-plastic mix	eures.
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ERRATA

Tables of Dielectric Materials, Vol. V

Page viii, line 6, for "0.1" read " < 0.1."

- " x, line 8, for "0.005" read " < 0.005"; for "l" read " > 1"; line 10, for "0.002" read " < 0.002."
- " 2, line 3 from bot., for "1.3," "1.7," "4.8" read "13," "1.3," "1.7."
- " 4, line 11, for "0.004" read "0.044"; line 13, delete "268" and "21.4."
- " 5, lines 6 and 7, raise to correspond with "Corning 7910."
- " 7, line 3 from bot., for ".3.68" read "3.68."
- " 8, line 4, for "-275" read "275"; line 5, for "33.27" read "3.27."
- " 11, line 6, for "--31" read "31."
- " 13, line 3, for "to film" read " \(_\) to film"; lines 9 and 11 from bottom of Table, change single to double asterisks.
- " 14, line 8, for "4.84" read "3.84."
- " 161 and 165, "Note," for "Km" read "K*."
- " 174, line 2, delete " "Fe."
- " 175, line 2, for "Cerqmivs" read "Ceramics."
- " 245, line 9, first column, for "Iv-58" read "IV-58."
- " 247, line 19, second column, for "159-175" read "159-176."
- "249, line 6 from bot., first column, for "133-139, 142-158, 177-180" read "133-136, 138,139,142-158, 177, 179, 180"; second column, line 2, for "V-140, 141" read "V-137,140,141"; line 3, for "176,181,182" read "176,178,181,182."

Laboratory for Insulation Research

Massachusetts Institute of Technology

In addition to the printed errata the following errors have come to our attention:

Page 6, Boron nitride, add these tan 8's:

f	tan 8
1×102	10.3
1×10 ³	6.5
lx10 ⁴	4.2
1x10 ⁵	3
lx10 ⁶	2.0
1x10 ⁷	1.4
lxlo ⁸	0.92

Page 39, tan δ at $l = 10^{10}$ should be:

To ^C	tan 8
26	0.00026
116	0.00029
206	0.00034
302	0.00044
412	0.00058
457	0.00069
499	0.00080

Page 52, "Wesgo" Al-300:

$$f = 9.5 \times 10^9$$
 instead of $f = 9.5 \times 10^{10}$; tan 8 scale should read:

0.0006

TABLES OF DIELECTRIC MATERIALS VOLUME V

Laboratory for Insulation Research

Massachusetts Institute of Technology

Cambridge, Massachusetts

The work reported in this document was made possible through support extended to the Massachusetts Institute of Technology, Laboratory for Insulation Research, jointly by the Navy Department (Office of Naval Research), the Army Signal Corps, the Air Force (Air Matériel Command), and the Ordnance Materials Research Office under ONR Contract Nonr-1841(10), NR-017-421. Reproduction of this article in whole or in part is permitted for any purpose of the United States Government.

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Tables of Dielectric Materials

Volume V

Laboratory for Insulation Research

Massachusetts Institute of Technology

Cambridge, Massachusetts

During World War II the Laboratory for Insulation Research assumed, in addition to other tasks, the responsibility of acting as a clearing house for dielectric information. It developed measurement techniques over wide ranges of frequency and temperature, provided data on materials of strategic importance and summarized the results in the "Tables of Dielectric Materials."

Volumes I and II were issued during the war. The termination of hostilities, however, did not end our obligation. Government and Industry relied on these data, and the idea had become entrenched that materials of general interest could be measured in our laboratory free of charge in return for background information required for the defense effort. Volume III was issued in 1948, and our clearing house activity stepped up when the outbreak of the Korean war emphasized the precariousness of the political situation. Volume IV, released in January 1953, summarized in expanded measurements all materials of importance at that time and was made generally available as Appendix to the book "Dielectric Materials and Applications" (Technology Press and John Wiley and Sons, New York, 1954). In the interim periods, the accumulating information aided Government agencies and industrial laboratories in the selection and development of dielectrics under Government contracts.

Since 1953 the missile age has arrived with its demands for hightemperature dielectrics. At the same time the concepts of "Molecular Engineering, "on which the Laboratory for Insulation Research was founded, are rapidly becoming public property: dielectrics are being made to order for an increasing number of new devices. These trends are reflected in Volume V of the "Tables" by extension to high-temperatures (Sec. III), ferromagnetics (Sec. IV) and attenuator characteristics (Sec. V).

Like its predecessors, Volume V is a storage bin of practical information, ill-adapted for theoretical analysis. Here are radome materials and glass cloth; jet fuel and compressed gases; Scotch tape, Kraft paper and Sauereisen cement, to mention only some of the more outlandish representatives. Here is demonstrated that impure raw materials cause inferior high-temperature performance and that overheating produces rapid degradation. There are also examples of beneficial action of heating in driving out detrimental moisture and volatile compounds. Trends are revealed for the development of better materials, and faulty manufacturing practices are exposed for remedial action. Our task here is an unbiased presentation of data, which leaves the users of the "Tables" free to draw their own conclusions.

A true dielectric analysis of materials requires a different approach: accurately defined materials; controlled variation of composition and structure; careful investigation of the influence of manufacturing parameters; and a comparison of the properties of multicrystalline materials with those of single crystals. This arduous task has been started in our laboratory for ferromagnetic semiconductors by a careful ceramics study of square-loop materials (G. Economos, Tech. Rep. 78, May, 1954; J. Amer. Geram. Soc., July through November, 1955); in an extensive broad-band investigation of ferrites from d.c. to the ultraviolet (A. von Hippel, W.B. Westphal and P.A. Miles, "Dielectric Spectroscopy of Ferromagnetic Semiconductors," Tech. Rep. 97, July, 1955, revised for Revs. Mod. Phys., July, 1957);

and by a detailed analysis of a special type of relaxation spectrum identified in ferrites (D. J. Epstein, "Domain-Wall Relaxation in Ferrites," Papers presented at the Conference on Magnetism and Magnetic Materials, Boston, Mass., Oct. 16-18, 1956, Amer. Inst. Elec. Engrs. T-91, 1957, p. 493).

The development of "Dielectric Spectroscopy" into a powerful tool of nondestructive analysis for the whole field of "Molecular Science and Engineering" should receive top priority in the use of our resources from now on. We intend therefore to terminate the service "Tables of Dielectric Materials" by the end of this year; a Volume VI will summarize ferroelectric and residual data. We hope that some independent and unbiased agency will continue this work of evaluating materials and acting as a clearing house for dielectric information.

Our venture was made possible through the ingenuity and indefatigable efforts of Mr. W.B. Westphal, group leader of the dielectric measurements group. Mrs. Barbara Beal East, his able co-worker for several years, measured most of the low field-strength data, supported in recent months by Mrs. Rhoda Yarkin. Mrs. Ann Miller and Frank Bispham gave technical assistance, and Miss Aina Sils and John Mara were of great help in the preparation of the final manuscript. The hysteresis data of Sec. IV were obtained by B. Frakiewicz with F. Bispham and under the general direction of Prof. D.J. Epstein, group leader of the ferromagnetics group.

The Laboratory for Insulation Research has operated under the joint sponsorship of the Navy Department (Office of Naval Research), the Army Signal Corps, the Air Force (Air Matériel Command), and the Ordnance Materials Research Office for many years in an atmosphere of mutual trust and understanding; we gratefully acknowledge this support.

Dielectric Parameters

- 1. ϵ'/ϵ_0 , the dielectric constant or permittivity relative to vacuum, also designated in the literature as K, κ_p , κ' , ϵ , ϵ' , D.C., etc.
- 2. κ' , same as ϵ'/ϵ_0 .
- 3. $\tan \delta$, the dielectric loss tangent or dissipation factor, also designated in the literature as DF, 1/Q, and when losses are low (0.1) as power factor or $\cos \theta$.
- 4. $\tan \delta_d$ or $\tan \delta_e$, same as $\tan \delta$.
- 5. ϵ''/ϵ_0 , the dielectric loss factor relative to vacuum, also designated in the literature as κ'' , ϵ'' . L.F., etc.
- 6. κ^{11} , same as ϵ^{11}/ϵ_0 .
- 7. μ'/μ_0 , the magnetic permeability relative to vacuum, also designated in the literature as μ' , μ_R , μ_0 , κ'_m .
- 8. κ'_{m} , same as μ'/μ_{o} .
- 9. $\tan \delta_m$, the magnetic loss tangent, also designated in the literature as 1/Q.
- 10. μ''/μ_0 , the magnetic loss factor in analogy to the dielectric loss factor; also designated in the literature as μ'' , μ_I , κ''_D .
- 11. $\kappa_{m}^{"}$ same as μ''/μ_{o} .
- 12. $\kappa''/(\kappa'_m)^2$, a figure of merit for core materials, also designated in the literature as loss factor, $1/\mu'Q$.
- 13. $\tan \delta_t$, the total loss tangent, the sum of $\tan \delta_d$ plus $\tan \delta_m$. Relations between parameters are discussed in Vol. IV. The ferromagnetic sections use the parameter κ''_m instead of $\tan \delta_m$, which becomes clumsy in the frequency region where κ' is close to zero or negative.
- 14. p, the a-c volume resistivity in ohm-cm.
- 15. σ , the a-c volume conductivity in mho/m.
- 16. a, the attenuation constant for propagation in free space in decibel per cm.

- 17. β/β_0 , the phase constant relative to vacuum for propagation in free space.
- 18. |Z|, the magnitude of the intrinsic impedance relative to vacuum for propagation in free space.
- 19. θ , the angle of the intrinsic impedance.

Measurements and Accuracy

The measurements have been made, in general, on only one batch of the material and refer, unless otherwise specified, to samples measured at room temperature (25 to 26° C) and room humidity (30 to 50% R.H.). Due to the wide variety of materials and improvements in techniques, no figures of general validity can be given concerning the accuracy of these measurements. For ϵ'/ϵ_0 , the nominal accuracy is $\pm 2\%$; the accuracy trends are toward $\pm 1\%$ for rigid, low-loss materials (tan $\delta=0.005$) and $\pm 5\%$ for high-loss materials (tan $\delta=1$). For tan δ_d , the nominal accuracy is $\pm 5\%$; for high-loss materials, the error may be $\pm 10\%$. For very low-loss materials (tan $\delta=0.002$), the accuracy is ± 0.0001 when the losses are given as multiples of 0.0001. When the loss is expressed in multiples of 0.00001, the error may be ± 0.00003 . For μ'/μ_0 , the nominal accuracy is $\pm 5\%$, for tan δ_m , $\pm 10\%$.

<u>Field strengths</u>. The linear dielectrics, those normally not field-strength sensitive, were measured at field strengths of approximately 50 volts per cm. in the frequency range 10^2 to 10^8 c/s and at lower field strengths at higher frequencies.

The ferromagnetic materials, unless otherwise noted, were measured at field strengths in their linear region. The values thus measured are the <u>initial</u> permeability.

For laminates, which are in general not isotropic, the direction of the electric field is perpendicular to the plane of the laminate for frequencies in the range 10^2 to $3 \text{x} 10^8$ c/s and parallel for higher frequencies unless otherwise specified.

Some metal-loaded materials have been measured which are slightly diamagnetic, but are not sufficiently homogeneous for precise separation of μ^* and ϵ^* . For these the product of dielectric constant and permeability and the sum of the loss tangents is given.

I. Tabulated Dielectric Data at Room Temperature (25 to 26 °C)

Values of tan δ are multiplied by 10 4 ; frequency given in c/s.	$\frac{1\times10^9}{1\times10^9} \frac{3\times10^9}{3\times10^9} \frac{8.6\times10^9}{1.4\times10^9} \frac{1.4\times10^{10}}{1.4\times10^{10}} \frac{2.4\times10^{10}}{5\times10^{10}}$	6.6	< 20					•						-1-				4.75	1.1				7.73	13	7.97	15	1939. d. Harshaw. e. Amer. Lava (dry values).
y 10 ⁴ ; fr	3x10 ⁸ 1		· · · · · · · · · · · · · · · · · · ·	11.53	^ 1													;	!				7.8	9.2	8.0	16 -	
tiplied b	1x10 ⁸ 3		< 10	11.53	< 10	•				٠									1				7.8	7.8	8.0	15	c. Data of S. Whitehead and W. Hackett, Proc. Phys. Soc. 51, 173
are mul	1×10^7		< 10	11.53	< 10													!					7.8	5.8	8.0	11	c. Phys.
of tan 6	1×10^{6}		< 10	11.53	< 10													-	!				7.8	7.4	8.0	7.9	ett, Pro
Values			< 10	11.53	< 10			244	15.					6.62	\ 2	5.97	\ 62	;	!				7.8	9.4	8.0	9.2	W. Hack
	$\frac{1\times10^4}{}$		< 10	11.53	< 10	59	< 40	246	27			5.68	\ 2	6.62	< 1	5.97	4		1 1				7.8	9.5	8.0	18	ad and
	$\frac{1\times10^3}{}$	9.53	< 2	11.53	\ 2	;	1	247	41	6.82	< 10	1	!	6.62	\ \ 1	5.97	9	;	} ! !	31.9	380		7.8	9.8	8.0	22	Whitehe
	1×10^{2}		< 10	11.53	< 10	1	!	249	62	1	-	1	!	6.62	2	5.97	10		1 1	} } }	-		7.8	11	8.0	9.7	ta of S.
		€1/€	tané	£'/€		e1/e		€1/€	tan 6	€1/€	tan 6	€¹/€ 0	tan 6	€1/€	tan 6	€1/€	tan 6	€1/€	tan ô	€1/€	tan ô		€'/€	tan 6	€1/€	tan 6	
	A. Solids, inorganic 1. Crystals	Aluminum oxide, sapphire ^a	(field 1 optical axis)	(field optical axis)		Barium titanate, hexagonal	(field L optical axis)	(field optical axis)		Calcium fluoride ^b		Carbon, diamond ^c		Cesium bromide		Cesium iodide		Potassium chloride		Thallium chloride		2. Ceramics a. Aluminas	"AlSiMag" 491 (blue) ^e		"AlSiMag" 513 (pink) ^e		a. Linde Air. b. Lab. Ins. Res.

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$c' \mid k_0 = 100$ $c' \mid k_0 = 10$ $c' \mid k_0 = $	1 A 9. Aluminos (2004)		200	500	41	5	9011	7.107	8	80	6	601	601-30	1 4.1010	9 4-1010	10
8.0 8.0 <td></td> <td>€، /و</td> <td></td> <td></td> <td></td> <td>1 X 1 O</td> <td>l xio</td> <td></td> <td>l i</td> <td>3X10</td> <td></td> <td>9x10</td> <td>5.80</td> <td>1.4x10</td> <td></td> <td>5.80</td>		€، /و				1 X 1 O	l xio		l i	3X10		9x10	5.80	1.4x10		5.80
8.0 8.0 8.0 8.0 8.0 8.0 7.9 10 7.5 5.5 4.2 3.4 4.0 6.4 7.0 10.0 11 1.0 1.0 1.0 1.0 1.0 1.0 1.0 11 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 11 1.0		o tan 6	1	1 1 1	;		;		1	1	!		10	!	!	10
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1.		tan 6		7.5	5.5	4.2	3.4	4.0	6.4	7.9	1	!	15			
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1 1 <th< td=""><td></td><td>tan 6</td><td>'</td><td>1</td><td>1</td><td>-</td><td>-</td><td>!</td><td>1</td><td>-</td><td></td><td>1</td><td>0.9</td><td></td><td></td><td></td></th<>		tan 6	'	1	1	-	-	!	1	-		1	0.9			
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<td></td> <td>ڊ_{، /}ڊ ^٥</td> <td>1</td> <td>1</td> <td>!</td> <td>!</td> <td>!</td> <td>† !</td> <td>!</td> <td>!</td> <td>1</td> <td>!</td> <td>7.85</td> <td></td> <td></td> <td>-2</td>		ڊ _{، /} ڊ ^٥	1	1	!	!	!	† !	!	!	1	!	7.85			-2
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<td></td> <td>ε, /ε^ο</td> <td></td> <td>i</td> <td></td> <td>; ; ;</td> <td>}</td> <td></td> <td>1</td> <td> </td> <td>1 1 1 1 1 1</td> <td>1 1</td> <td>8.02</td> <td></td> <td></td> <td></td>		ε, /ε ^ο		i		; ; ;	}		1		1 1 1 1 1 1	1 1	8.02			
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9.60 9.60 9.60 9.60 9.60 9.60 9.60 9.63 9.42 3.3 1.8 1.4 < 1		tan 5		5.4	6.8	2	9	^ 1	< 1	က	5.8	9.1	10*			
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12.8 12.1 10.7 9.43 9.13 9.10 9.10 9.10 9.05 9.05 290 577 953 585 120 1.3 1.7 4.8 4.8 8.0		tan 6	3.3	1.8	1.4	^ 1	1.5	4.5	4.2	2.5	4.0	0.9	15			
290 577 953 585 120 1.3 1.7 4.8 4.8 8.0		ε'/ε _ο	12.8	12.1	10.7	9.43	9.13	9.10	9.10	9.10	9.08	9.05	9.03			
		tan 6	290	577	953	585	120	1.3	1.7	4.8	4.8	8.0	15			

a. Amer. Lava (dry values).
 b. Coors (dry value).
 c. Corning.
 d. Diamonite.
 *Freq. = 9.3x10⁹ c/s.
 *This data superceded on page 21.

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I A 2a. Aluminas (cont.)		1×10^2	1×10^3	1×10^{4}	1x10 ⁵	1x10 ⁶	1×10^7	1×10^{8}	3x10 ⁸	1×10^9	$\frac{3 \times 10^9}{}$	8.6x10	1.4x10	2.4×10	5×10^{10}
Diamonite P-3530-40 ^a	€1/€	8,95	8.95	8.95	8.95	8.95			8,95	8.90	8.85	8.77			
	tan 6	7.8	5.4	4.6	က	2	8	8	œ	8.5	10.9	15			
Frenchtown 6096 ^b	€1/€	!	;	!	!	:	!	! !	!	8.17					
	tan 6	!	!	1	1	!				13					
Frenchtown 7873 ^{b,c}	€'/€	}	i ! !	;	;		!	;	!	09.9					
	tan 6	:	-		-	;		;		22					
General Ceramic ADH-211 ^d	€1/€°	1		:		1	1	† 	 		1	7.93			
	tan 6	-		-	-	-		1	-	1	!	9.5			
Kearfott High Purity Alumina	€1/€	9.40	9.40	9.40	9.40	! ! !	† † †	† • •	1 1	1 1 1	i ? ?	9.40	9.40	;	9.4
	tan 8	က	\ 2	\ \	\ ru	1	;	!!!!	:	1 1 1	1 1	1.8	1.5		1.7
"Sintox" ^f	€1/€		}	1	! !	! ! !	1		 	f f f	1	1 1	!	9.15	
	tan 6	1	!	;			i ! !	!	!	-	-	-	:	16	
Norton $7x^g$	€1/€	9.62	9.64	9.64	9.64	9.64	9.64	9.64		-	1	9.63	9.62		-
(density = 3.86 gm/cc)	tan 6	15.2	15.5	13.2	6	2.7	1.0	1.5	† † †	1 1 1	i 1 1	3.2	2.3		3-
Norton $17Z^g$	€1/€ ₀			!	!	;	1 1	1 1	!	-	1	9.20			
	tan 6	!	1	!	!	1	1	!	! ! !		1	9.0			
Raytheon 402B	e1/e0		:	!	-		-			-	! ! ;	9.42			
	tan 6	!		-		-			1		-	.14			
Stupakoff 1510 ^{i,j}	€1/€	!				1	1 1 1 1	;	:	!	!	5.72			
•	tan 6		!	1	!	1	!	1	1 1	!	1	16^*			
Stupakoff 1540 ^{1, K}	€1/€ ₀	!	;	1	!	!		-	1	.		8.97			
	tan ô	† † †	!	1	-	:	•	:		1 1	1	5.8			
Stupakoff 1542E ^{i,1}	e1/e	1	1	1 1 1		!			1 1	!	:	9.15			
	tan 6	:	1	1		!	1	1	1 1	1	} 	6.8			
Stupakoff 1542P ^{1, m}	e1/e	1	:	;	!	1 1	1	1	i i	!	} 	9.34			
	tan 6	1	;		1		-		1 1	!	-	5.5			
a. Diamonite. b. Frenchtown.	c. Alumina-mulite.	nina-m		d. Gen. Ceramics.	Ceram		e. Kearfott. f.	ott. f.	Nat' 1 F	Nat'l Res. Corp.	ņ	Norton, exp	perimental	Norton, experimental materials.	

c. Alumina-mulite. d. Gen. Ceramics. e. Kearfott. f. Nat'l Res. Corp. g. Norton, experimental materials. h. Raytheon. i. Stupakoff. j. 99.8% $A120_3$, 10% porosity. k. 95% $A1_20_3$, vitrified. l. 96% $A1_20_3$, extruded, m. 96% $A1_20_3$, pressed. *At 50% relative humidity. a. Diamonite.

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I A 2a. Aluminas (cont.)	(1)	1×10^2	$\frac{1\times10^3}{}$	1×104	1×10 ⁵	1×10	1×10	1x10 ⁸	3x10 ⁸	$\frac{1\times10^9}{}$	3x10	8.6×10	1.4x1010	2.4×10 ¹⁰	5×10^{10}
Stupakoff 1550a,b	ει /ε	1		-	-			!	1			7.72			
	tan 6		;	-				-		-	1	16			
"Wesgo" AL-300 ^{c,d}	ε¹ /ε°	:	9.6	9.6	9.6	9.6	9.6	1 1	9.6		!	9.63			
	tan 6	!	80	2.5	₩	-	0.7	1	1.6	1 1 1	1	5.5			
"Wesgo" AL-1009 ^c	e'/e,	1		1		!	-	-	1	1 1		7.03			
		f 	!!!				-	1 1	-	-	!	3.7			
I A 2b. Ferrites (Detailed data on other ferrites in ferromagnetics section).	on other fe	rrites	in fer	omagn	etics se	ction).	Values	of tan	are g	iven wit	thout mul	Values of $\tan \delta$ are given without multiplying factor.	tor.		
Magnesium manganite	ει /ε'	:	2710	869	98.3	24.6	18.4	15.5	1	12.1	11.2	10.9			
		-	6,62	2,95	3.90	1.66	0.41	0.18	1 1	0.081	0.004	0.018			
"Ferramic" H-1 ^e	e'/e		-	}	6940										
	tan 6d	1	;	!	2.03	1	268	21.4							
	μ' /μο	1	089	672	099	570	268	21.4							
	tan 8	;	-	1	-	90.0	0.42	3.9							-4-
"Ferroxcube" $105^{ m f}$	ει /ε°	;		1		:	11.9	!	11.2	11.0	11.0				•
	tan $\delta_{\mathbf{d}}$	1	-	1	;		0,070	;	0.07	0.034	0.014				
	- 'η', η	;	-	!	}	1 1	-	1	! ! !	3.53	0.57				
		1 1	1	;		}			1	2.50	6.75				
I A 2c. Steatite				>	alues o	f tan 6 a	re mult	iplied b	y 10 ⁴ ; f	requen	Values of $ an\delta$ are multiplied by 10^4 ; frequency given in c/s	in c/s.			
Gen. Ceramics BN-3054	€¹/€	!	; ; ;	1	!	1	-	-	1	1	1	6.34			
		-		!	;	!	!	-	:	;	:	18			
I A 2d. Wollastonites															
"AlSiMag" 577g	e1/e 6.	6.54	6.54	6.54	6.54	6.54	6.54	6.53	6.52	-	;	6.45			
•	tan 6	11	7.2	0.9	5.3	3.9	2.7	5.0	7.2	1	!	24			
Rutgers E-16 ⁿ	ει/ε°	-	!	}	-	6,38	-	1	1 1	1	-	6.35	\$ 8 8	6.34	
(density = 2.85 gm/cc)	-	!	1 1	1 1 1	i	1.9	!	1 1 1	† †	1	1	12.5		17.0	

a. Stupakoff. b. $83\%~\mathrm{Al_2}^0$ 3, balance principally silica and calcium oxides. c. Western Gold and Platinum. d. $97\%~\mathrm{Al_2}^0$ 3, remainder mostly MgO.

h. Ceramics School, Rugers University. e. Gen. Ceramics. f. Ferroxcube. g. Amer. Lava.

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I A 2e. Zircon		1x10	1x10	1x10	1x10	1x10	1×10	1x10	3x10	$1x10^3$	$\frac{3\times10^3}{}$	8.6x10	1.4x1010	2.4×10^{10}	$5x10^{10}$
"AlSiMag" 475 ^{4,5}	ε, /ε ₀	9.07	8.66	8.57	8.5	8.5	8.5	8.5	8.5	1	1 1	8.35	7.51*	7.45^{*}	
(density = 3.69 gm/cc)	tan δ	360	170	20	11	4.2	3.0	4.7	9.9		! ! !	27	33	50	
I A 3. Glasses															
Corning 7910	e1/e	3.80	3.80	3.80	3.80	3.80	3.80	3.80	3.80	i	!	3.79			
Corning 8603;	tan δ	4.1	4.1	4.0	3.8	3.3	3.0	2.7	2.6	!	1 1	5.0			
"Fotoform" B (843GU)	E1/E	-	6.82	1	}		1	1	1			6.29	6.26	6.20	
	tan 6	-	186	;	1	1	1	!	1 1	1	† 	137	149	195	
"Fotoform" B (843GZ)	e'/e		7.07	;				1	!	1 1) ! !	6.30	6.28	6.24	
	tan 6		257	1	1 1	;	!	!	1	} { 1	1 1	147	177	246	
"Fotoform" C (843GU)	ε1 /ε ₀	;	5.95	1	1	1 1	-	1			!	5.64	5.62	5,59	
	tan 6	;	58	;	!	:	-	1	;	:	;	117	134	165	
"Fotoform" C (843GZ)	e' /e ₀	;	6.01		!	-	-	† - -	! !	;	i ! !	5.71	5.70	5,69	
	tan ô	;	73	;	-	-	1 1	!		!	;	133	158	173	-5-
"Fotoform" E (843GU)	e' /e ₀	-	6.03	;	!	!!!	1	! ! !	1	! !	1	5.68	5.67	5.65	-
	tan 6	1	43	}	1	:	1	1	-	1	-	104	139	160	
"Fotoform" E (843GZ)	€¹ /€°	;	6.05	}	1	1	!	-	-	1 1 5	!	5.75	5.74	5.73	
	tan 6	1	73	:		-	:	1	-	;	!	123	160	168	
"Fotoceram" (843GU)	e, /e	!	5.62	!	!	-	-	-	-	! ! !	:	5.45	5,44	5.43	
	tan 6	1	71	!		!		1	† † †	1	-	82	94	103	
"Fotoceram" (843GZ)	e' /e ₀	!	5.63	-	!	1 1	-	1 1	1	1 1		5.46	5.45	5.44	
	tan 6	!	50	1	-	!	1 1 1	1	:	1	!	94	106	129	
"Ceram" 61-1 ^c	e1/e		!	1	1	1	-	!	!	:			5.39		
,	tan δ	!	į	-	;	-	-	!	1	1 1	!	!	4.5		
"Ceram" 61-2 ^c	e1/e	:	-	;	1	!	1 1	1	1	;	1		5.38		
	tan ô	!	!	† - - 	;	!	-	1	!		1 1	;	4.0		
"Ceram" 61-3 ^c	e1/e0	-	;	-	1	!	!	-	:	!	\$ 1 1	-	6.16		
	tan 6		i	-	-	!!!	1 1	-) []	1	:	-	4.0		
a Amer Lays h Zincon noncoloin	Join														

a. Amer. Lava. b. Zircon porcelain. c. Corning. *Density = 3.43 gm./cc.

Values of tan δ are multiplied by 10 ; frequency given in c/s.	ູ່ຜ
ues of tan δ are multiplied by 10^{4} ; frequency given	S
ues of tan δ are multiplied by 10^{4} ; frequency given	д.
ues of tan δ are multiplied by 10^{4} ; frequency	given
ues of tan 8 are multiplied by 10	frequency
ues of tan 6 are multiplied	4.,
ues of tan 8 are multiplied	10
ues of tan 6 are multiplied	by
ues of tan δ	ltiplied
ues of tan δ	re
nes of	ω
nes of	tan
nes	4
	nes

I A 3. Glasses (cont.)		1×10^{2}	1×10^3	1×104	1×10 ⁵	1×10 ⁶	1×10^7	1×10 ⁸	$3x10^8$	1×10^9	3×10^9	8.6×10	1.4×10^{10} 2.4×10^{10}	5×1010
	e¹ /e											!	6.14	
	tan ô	}	:				;		-	-	1 1 1	!	2.0	
	ει /ε _ο		;	1	!		1	1 1	1		1 1		5.85	
	tan δ	1	1 1	1	1 1 1		1	1	!	;		!	2.5	
Owens-Corning CR-262 ^b	et /e	7.14	7.05	7.00	6.95	6.95	6.94	6.88	6.84	!	:	6.79		
	tan 6	92	20	55	46	42	40	47	55	!	1	130		
	e1/e	6.52	6.50	6.50	6.48	6.50	6.49	6.46	6.44	-	1 1	6.42		
	tan δ	21	19	18	16	17	19	25	28		1	52		
	€¹ /€	7.26	7.16	7.12	7.10	7.09	90.7	7.00	86.98	1		6.92		
	tan 8	115	78	29	20	44	45	51	64		1 1	140		
	€1/€	6.64	09.9	6.59	6.57	6.56	95.5	6.55	6.53	!		6.51		
	tan 6	30	21	18	15	14	18	23	28	-	:	22		
	e1/e	4.07	4.07	4.07	4.06	4.06	4.06	4.06	4.05	1		4.02		- (
	tan 6	7.4	5.8	4.0	4.0	4.8	6.8	9.3	11	;	1 1 1	1.7		S-
	ει /ε ₀	!	1	:	!	1 1	}	-	!	;	!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!	3,79		
	tan 6			1	-	1	!	1	-	;	:	1.1		
Fused Quartz, Translucent	ει /ε ⁰	-	}	1	;		-	! ! !	!	1		3.65		
	tan 6	1	:	:	;	} ! !		;	!	1 1 1	-	2.6		
ro I	,									*	*	*		
_	د، <i>ا</i> د 0	4.15	4.15	4.15	4.15	4.15	4.15	4.15	!	4.80	4.80	4.80		
to direction of pressing) ^d	tan 6	1	1	!	1	1	!	! ! !	!	0.57	$1.6^{\text{+}}$	3.1		
	e1/e	4.81	2.45	1.91	1.75	1.67	1.64	1.62	1.60	1.74	1.64	1.61	1.6	
	tan 6	6500	4100	1180	400	170	140	170	250	460	470	250	360_	
	ει /ε _ο	-	1	;	-	1	}	1 1	t ! !	;		;	5.02	
	tan 6	1	† † 1			!	1	1	!		:	:	300	

a. Corning b. Research samples (Owens-Corning Fiberglas). c. Syncor. d. Hot-pressed (Carborundum). e. Aluminum-silicate ceramic fibers. * Electric field \(\pm\) to direction of pressing.

Values of tan δ are multiplied by 10; frequency given in c/s.

5×10^{10}												-	·7-													
2.4×10																										
1.4x10 ¹⁰																										
8, 6x10	2.49	49	0.992	45	3.08	53	0.960	52	5.35	75	0.961	101					6.94	24								
$\frac{3\times10^9}{}$;	1	:	1	1	1	1 1	f 1 5	1 1 1	!!!	1					!	† 1 3 1			3,43	54				
1x10		1	1	;	† † !	1 1	1	1	!	1	1 1	;					!	!			3,43	54				
3x10 ⁸		\$ 6 1	1	1 1		1 1 1			!	!	1	:					1	1 1			!	!				
1x108		-	-	 		1	! ! !	-	1 1	!	1	1 1					-	1	4.8	620	3.43	26	3.68	22	3.67	15
1×10^7		1	!	!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!	1	1 1 1	1		-	1	1	!					1	-	5.5	1100	3.44	90	3.69	17	3.67	15
1x10 ⁶		!	!	1	!	-	!	† ! !) 	1					1	!	6.8	2900	3.46	82	3.69	23	3.67	17
1×10^{5}		;	1	!	1	;	1 1	:		-	-	1	98.9	160				-	10.5	7800	3,49	190	3.71	78	3.67	23
$\frac{4}{1\times10}4$			}	1	;	:	;	;	!				8.93	725	5.07	28	1 1	1	21	19300	3,55	400	3.76	210	3.67	33
1×10^3	2.62	175			3.02	130	1		5.48	143	-	;	13.9	2000	5.10	32	1	;	0.2	38600	3.80	1300	3.97	290	3.68	46
$\frac{1\times10^2}{1}$	-	1 1	!	1	;	;	1	-		}	;		40	8400	5.15	46		-	270	86500	4.55	3900	4.55	1240	3.70	69
ont.)	د' / د	tan 6	μ' /μ	$ \tan \delta $	€' / €	tan ô	μ'/μ	tan 8	e' /e	tan 6 _d	μ' /μ	tan 6	€' /€	tan 6	e¹ /e	tan 6	€' /€	tan δ	e' /e	tan δ	e' /e,	tan 6	€1/€	tan 6	€1/€	tan 6
IA 4. Miscellaneous Inorganics (cont.)	"Eccofoam" HiK $(1000^{\rm o}F)$ -2.5				"Eccofoam" HiK (1000ºF)-3ª				"Eccofoam" HiK (1000oF)- $5^{ m a}$				Pipestone (50% R.H.)		Pipestone (baked, then	paraffin impregnated) ^{b,c}	"Supramica" 500 ^d	(density 3.04 gm/cc)	Sauereisen Cement No. 1	(after wet grinding)	Sauereisen Cement No. 1	(after drying at 200°C)	"Mica-ramic"	(as received)	"Mica-ramic"	(after drying)

a. Emerson and Cuming. b. Hunson. c. Paraffin treated (Lab. Ins. Res.). d. Mycalex. e. Spruce Pine Mica.

I B. Solids, organic

	10	5x10												-	8-							
	0,,,,	2.4x10															4.47	435	4.73	330	4.22	230
	1, , , , 10	1.4x10															4.51	403 *	4.74	280 *	4.23	215^*
n c/s.	6	8, 6x10	3.43	360	33.27	230	3.32	377	3.13	234	3.47	384	3.44	327	1.41	115	4.57	390*	4.75	250	4.23	230
Values of tan δ are multiplied by 10^4 ; frequency given in c/s.	60,	3x10	;	!	3.28	280	!	1	3.20	223	1	!	3.49	268	!	:	1		4.76	190	!	;
equenc.	60111	IXIO	3,50	312	3.29	280	3,50	364	3.24	215	3.62	341	3,54	257	!	1	4.74	410	4.78	160^*	;	1
10 ⁴ ; fr	8	3×10	1	!	1	1		:	3,30	206	;	1 1	3.63	245	!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!	1	4.5	194	4.3	151	3.7	164
olied by	80	01X1	3.52	-275	3.32	240	3.61	440	3.35	199	3.74	310	3.70	244	}	!	4.60	175	4.34	111	3.78	66
e multij	701.10	1x10	3.66	271	3.40	202	3.85	517	3.45	186	3.90	248	3,85	212	-	;	4.72	390	4.44	98	3,84	72
an 6 ar	1.10	IXIO	3.80	270	3.51	190	4.21	802	3.56	802	4.05	245	4.00	218	1	!	5.11	1070	4.51	72	3.87	47
nes of t	1 210 5	OTXI	3.95	231	3,61	167	4.73	006	3.68	235	4.18	261	4.15	243	-	!	6.64	2610	4.56	69	3.91	42
Val	1~104		4.06	157	3.69	114	5.25	922	3.78	200	4.35	270	4.30	264	1	-	10.5	3340	4.60	99	3,95	47
	1 103	OTYT	4.12	100	3.72	99	6.03	1060	3.88	161	4.54	295	4,49	325	} !	; ; ;	17.1	2880	4.64	39	3.98	43
	1×102 1×103	0141	4.17	103	3.75	59	7.42	1760	3.99	192	4.75	346	4.74	440	† ! !	;	25.3	2350	4.66	35	4.01	37
			ε' /ε ₀ 4.17	tan ô	€1/€	tan ô	€¹/€ ₀ 7.42	tan 6	د'/د 3.99	tan 6	, o _{≥/,>}	tan δ	ε, /ε ₀	tan 6	e' / e	tan 6	e' / e	tan 8	e' / e	tan 6	د، /د	tan 6
1. Plastics (including plastics	with fillers, laminates).	a. Phenolics	Phenolic impregnated	"Dacron" batt ^a	Phenolic impregnated	woven "Dacron" fabric	Phenolic impregnated	"Nylon" batt ^a	Phenolic impregnated	woven "Nylon" fabric	Phenolic impregnated	"Orlon" batt ^a		fabric	"Eccofoam" GL ^b		laminate,	pressed (dried) ^c	Phenolic-"fiberglas" laminate e'/e	laminate pressed (dried) ^d		laminate bagged (dried) ^e

IB 1 b. Melamine-formaldehyde

140
143
139
130
98
99
49
49
44
46
46
tan 6
laminate) GM-1, (dried) ¹

a. du Pont Textile Fibers Dept. b. Emerson and Cuming. c. "Pyrotex 9526D2, 8 oz. mat (Raybestos Manhatten) with 34% Conolon 506 resin (Narmco) molded at 290°F, 200 psi and cured at temperatures to 400°F (Goodyear). d. 181-14 "Fiberglas" cloth with 31% resin as in (c), molded at 310°F, cured at 350°F (Goodyear). e. Composition same as (d) but with 3-ply bleeder. f. 50% Amer. Cyanamid 405 resin, 50% Owens-Corning T-36 glass mat (Continental Diamond).

*Sample not dried.

Values of tan δ are multiplied by 10; frequency given in c/s.

IB1 c. Cellulose derivatives		1×10^2	$\frac{1\times10^2}{1\times10^3}$	1×104	$\frac{1 \times 10^{5}}{1 \times 10^{2}}$	1x10 ⁶	1×10^7	1×10^{8}	3×10^8	$\frac{1\times10^9}{1}$	3×10^9	8.6×10	1.4x10 ¹⁰	2.4×1010	5×10^{10}
"Forticel" JLB-(H)a	e1/e	3.59	3.57	3.51	3.41	3.29	3.18					2.89			
	tan 6	61	66	159	196	194	180	205	-	264	294	334			
"Forticel" JMB-(M) ^a	e' / e	3.94	3.89	3.82	3.70	3.55	3,41	3.25	† 	3.06	2.97	2.88			
e e	tan 6	89	109	182	240	251	260	319		392	434	389			
"CTA" ^b	€¹ / €	4.11	3.99	3.86	3.67	3.51	3,38	3.23	!	3.07	3.01	2.92			
	tan 8	140	206	277	306	306	281	218		191	206	226			
IB 1 d. Silicon resins															
Silicone Alloy C-1147 ^c	ε ^ι / ε ₀	}	1 1	1	1	2.52	2.52	2.52	2.52	2.51	2.50	2.49	2.48	2.48	2.48
	tan ô		!	-	1	9.0	2.5	3,3	4.0	5.0	0.9	7.1	8.1	0.6	14.2
Silicone Alloy C-1328 ^c	€1/€	}	}	!		2.50	2.50	2.50	2,49	2,49	2,48	2.48	2.48	2,48	2.48
	tan δ	;	!!!	1		1.2	3.4	2.2	1.9	2.8	3.2	4.0	4.4	4.8	5.9
DC 301 molding compound	€¹ / €	4.16	4.12	4.10	4.08	4.07	4.06	4.04							-:
	tan ô	63	63	53	49	20	51	29							9-
DC 2105 laminate	€1/€	3.98	3.98	3.97	3.96	3.96	3.96	3.96	1	4.18	4.17	4.16			
	tan 6	19.3	18.6	15.9	15	14.4	16.6	25	† † 1	28	61	69			
DC 2106 laminate	€' / € 4.24	4.24	4.24	4.22	4.22	4.21	4.21	4.21	!!!	4.32	4.31	4.30			
	tan 6	23	18.2	15.2	12	14	17	23	1	45	52	99			
Silicone - asbestos	€ / € 12.80	12.80	9.90	6,65	4.59	3.68	3,45	3.39	3,3	3.68	3.58	3.52	3.49	3.49	
laminate ^g	tan 6 1870	1870	2400	2650	2090	1020	460	20	45	200	340	210^*	190	130	
Silicone - "fiberglas" laminate, e'/e, 3.66	e1/e	3.66	3,63	3.61	3.60	3.59	3.58	3,56	3.5	3.91	3.88	3.85	3.83	3.81	
pressed (dried) ^h	tan § 10.7	10.7	9.8	8.7	9.4	10.0	12.2	19	26	33* 8	43*	65	75*	113*	
Silicone - "fiberglas" laminate, ϵ'/ϵ_0	, e'/E	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.1	;	3.84	3.80	3.78	3.75	
hagged (dried)	tan 6	21.3	16.7	15.4	14	13.2	13.1	19.3	24	! !	56 *	402	* 88	110	

a. Cellulose propionate (Celanese). b. Cellulose tri-acetate (du Pont Film Dept.). c. Delaware Res. Dev. d. 45% chopped glass fibers, 20% silica, 35% polysiloxane resin (Dow-Corning). e. 50% EC-116 glass fabric, 50% polysiloxane resin (Dow-Corning). g. 50% "Pyrotex" felt 9526DB-5, impregnated with 50% DC-2106 resin (U.S. Polymeric), molded at 350°F, 300 psi, and cured at temperatures to 470°F (Goodyear). h. 65% 181-112 cloth, 35% DC-2106 resin molded at 315°F, cured at temperatures to 480°F (Goodyear). i. Composition same as (a), but with 3-ply bleeder, 33% resin.

* Not dried.

Values of tan δ are multiplied by 10 ; frequency given in c/s.

IB1e. Polyvinyl resins		•	•		1		ı		•	•	((•	,
(1). Polyethylenes		$\frac{1\times10^2}{1}$	1×10 ³	$\frac{1\times10^4}{1}$	1x10 ⁵	1x10	1×10	1×10 ⁸	3x10 ⁸	$\frac{1 \times 10^9}{1}$	$\frac{3\times10^9}{}$	8.6×10	1.4x1010	2.4×10 ¹⁰	5x1010
"Fortiflex" A ^a	e 1/e	2.39	2.38	2.38	2.38	2.38	2.38	2.38		2,38	2.38	2.37			
	tan 6	1.1	0.37	0.25	<0.5	<0.3	<0.3	0.3	-	3.1	2.6	1.9			
"Marlex" 50 ^b	e 1/e	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2,39	2.39	2.38	2.38	2.38	
	tan 6	1.6	0.33	0.28	<0.5	0.28	<0.3	0.32	0.9	2.4	2.15	1.6	1.9	2.1	
(2). Polyvinyl chloride-acetate															
"Boltaron" 6200-10 ^c	ε'/ε₀	!		1	}	1		\$!		2.81					
	tan 6	1	1	!	1	1	1	-	-	82					
(3). Polychlorotrifluoroethylene "KEL-F" X200 ^d	e /e	3.13	3.00	2.84	2.70	2.56	2.45	2.36	!	2.30	2.28	2.27			
	tan 6	198	292	398	420	320	220	180	-	96	73	56			
(4). Polytetrafluoroethylene															
"Teflon" (77%) plus	e 1/e	;	1	-		:	!	} } {	!	2.38					-
calcium fluoride (23%) ^e	tan 6	! ! !	!	;		:		1	i i i	57					10-
(5). Polyacrylates															
"Lucite" Type HC-202	د، /د	3.27	3.01	2.87	2.76	2.71	2,66	2.63	1	2.58	2.56	2.55			
	tan 6	290	446	300	202	142	06	63	-	43	37	33			
Acrylic impregnated	e, /e	3.76	3.47	3.25	3.10	2.98	2.91	2.84	-	2.77	2.74	2.72			
Orlon batt ^g	tan 6	664	503	362	277	213	168	118		98	72	29			
(6). Polystyrene															
Polystyrene impregnated	€' /€ ₀	3.11	3.10	3.10	3.10	3.10	3.10	3.10	;	3.16	3.16	3.16			
"Fiberglas" g	tan 6	22	24.6	18.2	15.6	4.6	6.1	11.3	1	28	39	36			
Polystyrene impregnated	ε, /ε ⁰	3.02	3.01	3.00	3.00	3.00	2.97	2.91	;	2:87	2.84	2.82			
"Dacron" batt	tan 6	43	30	32.6	46	09	62	78		113	130	157			
Polystyrene impregnated	e' /e _o	3.09	2.98	2.92	2.89	2.87	2.86	2.85	-	2.89	2.88	2.87			
"Orlon" batt	tan 6	211	159	113	78	45	33	26	•	56	28	36			
"Eccofoam" PS (K=1.2) ^h	6'/E	!	}	1		; ;	-	-		;		1.182			
	tan 6	:	;	;	;			-		1 1	;	1.2			

a. Linear polyethylene (Celanese). b. Low pressure, hi-density polyethylene (Phillips). c. 100% unplasticized polyvinyl chloride (Hartwell). d. Kellogg. e. Ethylene Chem. f. Methyl methacrylate (du Pont Polychemicals). g. du Pont Textile Fibers Dept. h. Samples also measured having ϵ^{1}/ϵ = 1.362, tan δ = 0.00165 (Emerson & Cuming).

Values of tan δ are multiplied by 10; frequency given in c/s.

IB 1 e. Polystyrene (cont.)		(ď	•	ı		·		c	c	c	c	-	-	-
(7). Miscellaneous polystyrenes		$\frac{1\times10^2}{1}$	$\frac{1\times10^3}{1}$	1x104	1x10 ⁵	1x10°	1x10	1x10	3x10°	1x10g	3×10	8.6x10	1.4x1010	2.4x1010	5x1010
Polytrifluorostyrene (film) ^a	€1/€	2.56	2.56	2,56	2.56		2.56	2.56		!	!	2.54			
	tan 6	34	22	16.5	14	6.2	6,3	6.9) E t	!	;	19			
Polycyclostyrene	e, /e	;	;	!	1	1	1	1	-	1	2.51	2.49			
	tan ô		1	}	!	1	1 1	1	!		31	56			
(8). Styrene copolymers, cross linked	linked														
"Pelron" 9420 ^c	€¹ /€	!	!] []	-	£ 5	1	2,59	2.54				
	tan 6	! !	!	; ; ;	-	-	1 1 1	1 1	; !	22	29				
"Pelron" 9422 ^c	€1/€	!	† † !	-		!		1	!	2.61	2.61				
	tan 6	1	;	1 1	!	! ! !	!		1	44	51				
"Pelron" 9423°	€1/€	!	!	!	!		;		-	2.62	2.61				
	tan 6	!			;	-	1	;	!	20	59				
"Pelron" 9424 ^c	€1/€	!	. !	1		1	1		!	2.60	2.60				
	tan 6	1	-	-		1	!	;	1 1	30	39				-1
"Ecco" L65 ^d	€1/€	!			1 1 1		1 1 1	1 1	!	2.58	2.58				1-
	tan 6	;	1	į	1	1	1	!] ; !	30	34				
"Stycast" LoK ^d	e1/e0				1	1	!	1 1				1.68			
	tan 6		i	:	;	1 1	}		† ! !	:	1	26			
"Stycast" HiK (K=7) ^{d,e}	€1/€0	7.25	7.15	7.08	7.06		7.03	!	1 1	!		6.85			
	tan 6	66	61	36	23	1	9.5	!		1		11			
"Stycast" TPM-3 ^d	€¹ /€ ₀	2.40	2.40	2.40	2.40	2.39	2.37	2,36	1	!		2.35			
	tan 6	2.9	1.7	1.9	2.8	7.3	7.2	5.8	!	:	!	4.6			
"Rexolite" 2101 ^h	ε, /ε _ο	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.72	† 	1	2.75			
	tan 6	13.5	9.6	7.5	5	44	6.5	10	12	† 1 1		19			
I B 1 f. Polyesters															
"Atlac" 382 (70%)-styrene	e1/e	3.08	3.05	3.02	3.00	2.96	2.92	2.87	1	2.82	2.78	2.72			
(30%) ⁱ	tan 6	82	75	10	80	110	132	142	!	135	120	105			

a. Polaroid. b. Monsanto, Ohio. c. East Coast Aeronautics. d. Emerson and Cuming. e. Manufactured with K=3 to 15. h. "Fiberglas" laminate (Rex). i. Atlas Powder.

Values of tan δ are multiplied by 10^4 ; frequency given in c/s.

	$\frac{1\times10^2}{1\times10}$ ϵ'/ϵ_0 2.91	$\frac{2}{2.90}$	$\frac{3}{1 \times 10^4}$	1x10 ⁵ 2.87	$\frac{1\times10^6}{2.84}$	$\frac{1\times10^7}{2.82}$	$\frac{1 \times 10^8}{2.77}$	3x10 ⁸	$\frac{1 \times 10^9}{2.72}$	$\frac{3 \times 10^9}{2.69}$	8.6×10 2.65	1.4×10 ¹⁰	2.4x10 ¹⁰	$\frac{5\times10^{10}}{10}$
tan 6 42 44			44	54	73	90	115	1	108	92	75			
ϵ'/ϵ_{o} 2.22 2.05			1.97	1.90	1.84	1.78	1.73	!	1.69	1.67	1.65			
tan ô 1006 396			255	218	200	210	240		235	200	200			
ε' / ε ₀ 4.65 4.57			4.53	4.50	4.45	4.43	4.40	:	4.40	4.35	4.30			
tan 6 48 45			41	63	7.7	96	120		95	102	106			
€¹/€ ₀ 3.43 3.40			3,36	3.32	3.26	3.17	3,11	1	2.97	2.93	2.86			
tan δ 65 61			78	125	148	143	160	1	147	124	114			
$\epsilon' / \epsilon_{o} 3.11 3.06$			3.06	3.02	2.98	2.97	2.94	1	2.91	2.89	2.82			
tan 6 22 27			46	79	83	87	128	1 1	145	130	129			
$\epsilon^{1}/\epsilon_{0}$ 5.55 5.26			4.98	4.70	4.42	4.15	3.86	:	3,55	3.42	3,28			
tan 6 360 360			370	370	370	200	009	1 1	570	470	380			
ε' /ε ₀ 3.91 3.81			3.71	3,63	3.56	3.47	3.33	-			!	2.96	2.94	-1
tan 6 20 2 172			162	162	161	195	320	!	!	1 1	;	410	288	12-
e¹/€ _o 3.37 3.35			3.32	3.28	3.20	3.13	3.05	3,03	3,00	2,99	2.98			
tan 5 48 51			98	152	182	179	143	123	98	81	89			
e¹/€ _o 3.61 3.53			3.47	3.37	3.26	3.15	3.07	!	3.03	3.02	3.01			
tan 5 119 111			135	185	226	223	202	1	144	105	113			
$\epsilon^{1}/\epsilon_{0}$ 2.99 2.96			2.89	2.86	2.83	2.77	2.71	1	2.74	:	2.65			
tan 5 39 47			80	127	152	152	137	1 1	92	!	93			
$\epsilon^{1}/\epsilon_{0}$ 3.84 3.72			3.59	3.45	3.32	3.22	3.09	3,05	3.00	2.96	2.91			
tan 8 309 239			255	283	261	185	137	126	113	105	26			
ϵ'/ϵ_0 3.16 3.12			3.04	2.93	2.86	2,77	2.54	1 1	2.92	1	2.89			
tan 5 133 146			196	233	228	197	167	!	84	1 1	92			
$\epsilon^{1}/\epsilon_{0}$ 3.72 3.61			3.50	3.40	3.31	3.24	3.18	3.15	3.13	3.11	3.08			
tan 6 277 200			184	187	186	170	139	120	100	92	89			
e¹/€ ₀ 4.08 3.90			3.78	3.68	3,60	3.51	3.39							
tan 6 337 258			201	179	160	141	125							

a. Atlas Powder. b. Phenolic spheres in polyester resin (Bakelite). c. Continental Diamond. d. Rohm and Haas', "Paraplex" P-43 resin (du Pont Textile Fibers Dept.).

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$\frac{1 \times 10^2}{1 \times 10}$
tan 8 19.1 41.0 89.9 145
è'/e 3.37 3.36 3.33 3.29
$\tan \delta$ 15 36 84 140
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Values of tan δ are multiplied by 10^4 ; frequency given in c/s.

 5×10^{10}

2.4×10

1.4×1010																										
8.6×10	4.64	213	4.42	210	4.64	218	3.16	240	3.12	250	3,06	280	3.12	270	3.15	181	3,32	280	2.41	160	4.53	270	5.85	460	7.54	460
3×10	4.67	176	4.48	182	4.73	202	3.21	260	3.15	300	1 1	t i	3.25	310	!	1	3.38	300	1		:		-	1	1	
1×10^9		170	4.54	186	4.80	179	3.25	270	3,18	310	3.24	320	3,33	320	3.32	204	3,45	310	1 1	!	:		;	1	1	;
3x108		162	4.65	175	4.85	165	1	1	1	}	1	-	!	-	1	1	-	;	-		1	1	1	1	1 1	}
1x10 ⁸	4.66	233	4.63	223	4.65	268	3.37	300	3,30	256	3,45	330	3,53	343	3.54	268	3.57	310	1 1	!	1 1	1	:	-	-	1
$\frac{1\times10^{7}}{1}$	4.76	205	4.75	202	4.77	226	3.49	300	3,39	248	3.64	323	3.61	314	3.69	233	3.68	237	-	}	1	1	;	!	-	
1x10 ⁶	4.90	185	4.91	192	4.90	204	3.66	290	3.49	194	3.78	336	3.72	304	3.81	203	3.76	215	;	1 1	!	1		!		
1×10 ⁵	4.99	176	5.00	190	5.03	178	4.84	277	3.59	158	4.03	407	3,91	334	3.93	235	3.89	229		}	}	1	1	!		1
1×104	5.10	118	5.12	136	5.14	131	4.00	208	3.66	102	4.28	369	4.11	285	4.07	257	4.02	236	† ! !	} ! !		1	-	1		1
1×10^{3}		72	5.21	74	5.21	29	4.08	107	3.69	51	4.48	253	4.26	183	4.23	284	4.18	251					•	Ε		m
$\frac{1\times10^2}{1}$	5.20	46	5.25	09	5.25	42	4.12	49	3.71	32	4.62	189	4.34	125	4.42	332	4.35	304	η/ιμ.	+ tan 6	η/ιμ.	+ tan 6	η/ ιμ .	+ tan 6	η/ ιμ .	+ tan 6
	nate) e'/e	tan 6	nate) e' /e	tan 6	e1 /e	tan 6	€ 1/€	tan 6	€1/€	tan 6	et / e	tan 6	e1/e	tan 6	e1/e	tan 6	€1/€	tan 6	€1/€	tan 6	ڊ _ا /ڊ ^ي	tan 6	e'/e,	tan 6	€¹ /€	tan 6
IB1g. Epoxy resins	"Dilecto" (Epoxy-glass laminate)	$ ext{GB-116E}^{ ext{a}}$	"Dilecto" (Epoxy-glass laminate)	$\mathtt{GB-126E}^{\mathrm{a}}$	"Dilecto" (Epoxy-glass laminate)	$\mathtt{GB-181E}^{\mathrm{a}}$	Epoxy impregnated	"Dacron" batt ^b	Epoxy impregnated	woven "Dacron" fabric	Epoxy impregnated	"Nylon" batt ^b	Epoxy impregnated	woven "Nylon" fabric	Epoxy impregnated	"Orlon" batt ^b	Epoxy impregnated	woven "Orlon" fabric	"Eccofoam" HiK (500°F)	$(K = 2.4)^{C}$	"Eccofoam" HiK (500°F)	$(K = 4.5)^{C}$	"Eccofoam" HiK (500°F)	$(K = 5.9)^{c}$	"Eccofoam" HiK (500°F)	$(K = 7.5)^{C}$

a. Continental Diamond. b. du Pont Textile Fibers Dept. c. Emerson and Cuming.

Values of tan δ are multiplied by 10; frequency given in c/s.

$\frac{1.4 \times 10^{10}}{2.4 \times 10^{10}} \frac{2.4 \times 10^{10}}{5 \times 10^{10}}$													-1	15-												
8.6×10 1	3,95	326	1.115	880	2.00	334	1.40	1890	8.60	338	1,66	3900	13.6	220	1.12	0009	17.2	380	1.96	7300	2.81	116	1	-	3,10	
3x10		1	-	-	1	1 1	! ! !	ŗ	!	! !	1	1	; ; ;	}	2.34	4820		!	2.57	2600	2.83	120	3.27	099	3.23	
1x10		1 1		- 1 - 1	! ! !		- I	† † †	1	 	}	1	1	-	3,75	2650	 	}	4.31	2950	2.84	132	3.30	635	3.40	
3x108		!	1	}	1 1 1	* 1	1	1	!	1	1	1		1 1 1	3,90	570	!	1	4.69	260			1 1	1	!	
1x108		!	-	1 1 1	!	1	-		1	1 1		1	16.9	394	4.20	<200	19,6	420	4.80	<200	2.90	180	4.3	1100	3.70	
1×10^7	!		1 1 1		1	 		1 1		\$ 1 9		-	17.1	307	4.22	001⊳	19.9	390	4.85	<20	3.01	146	5.8	2300	4.35	
1x10		!	1	1	1	;		;	:	;		1 1	18.1	254	4.22	<100	21.4	360	4.85	<100	3.10	133	7.3	1000	4.90	
1×10 ⁵		234	1.33		6.55	247	1.67		10.8	255	2.64	-	18.5	228	4.22	-	1		4.85	;	3.15	108	8.1	540	5,60	
1x104		161	1.33	1	6.72	162	1.67	!	11.2	181	2.64	-	19.2	177	4.22	1	23.2	250	4.85		3,19	74	8.9	670	6.45	
1x10 ² 1x10 ³		}		}		}	:	;	;	-	}		19.6	128	4.22	3 1 1	23.9	144	4,85	:	3.21	44	9.4	1160	7.56	
1×10^2		i 1 1	-	!	;	1 1	1		:		1	;	19.9	134	4.22	:	24.2	94	4.85	;	3.22	34	9.7	2600	8.80	
	€, /€	o tan 6	μ' 'μ	tan 6	ει /ε ^ο	tan 6	η/ 'μ	$\tan \delta$	e1/e	tan 6	η/ 'μ	tan 6	ει /ε	tan 6	η/ ιμ	tan 6	ε' /ε _ο	tan 6	η/ η	tan 6	ε' / ε΄	tan 6	€1/€	tan 6	€¹/€	•
IB 1g. Epoxy resins (cont.)	"Eccosorb" MF110 ^a				"Eccosorb" MF112 ^a				"Eccosorb" MF114 ^a				"Eccosorb" MF116 ^{a,b}				"Eccosorb" MF117a,c				"Hysol" 6000 HD ^d		"Hysol" 6030-B ^d		"Hysol" XL-6060 ^d	

a. Emerson and Cuming. b. 81.2% Carbonyl iron, 18.8% resin. c. 85.8% Carbonyl iron, 14.2% resin. d. Houghton Labs.

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IB1 g. Epoxy resins (cont.)		1×10^{2}	1×10^3	$\frac{1\times10}{}$	$\frac{1\times10^{5}}{1}$	1×10^6	$\frac{1}{1}$	1x108	3x108	1x10	$\frac{3\times10^9}{}$	8.6x10	1.4x1010	2.4x10 ¹⁰	$\frac{5\times10^{10}}{}$
	€1/€	3.70	3.55		3.34	3.28	3.20	3.06	-	2.86	2,83	2.81			
	tan 6	77	69	80	126	194	280	270	!	215	194	195			
"Scotchply" type 1001 ^b	€1/€	6.60	5.98	5,59	5.32	5.10	4.89	4.71		4.59	4.48	4.38			
	tan 6	571	458	342	207	219	288	384		450	470	460			
"Scotchply" type 1001 ^b	€' / €	5,18	5.12	5.02	4.92	4.82	4.68	4.57		4.56	4.56	4.56			
	tan 6	78	97	139	166	184	199	194	!	178	168	152			
"Epon" 828-curing agent CL	e¹ / e	4.56	4,48	4.34	4.12	3.91	3.72	3,55	!	3,29	3.23	3.23			
	tan 6	61	150	290	370	340	340	360		310	310	330			
"Epon" 828-curing agent D ^C	€' / €	3.58	3,55	3,52	3.47	3,36	3.27	3.18	1	3.03					
	tan 6	27	45	88	170	230	270	240	:	250					
"Epon" 828-curing agent	€1/€	3,61	3.61	3,59	3.56	3.47	3,38	3.27		2.94					
	tan 6	18	23	99	130	180	220	260	8 8 8	270					
"Epon" 828-curing agent	€' / €	3.84	3.84	3,79	3.68	3.51	3,37	3.30	3.14	3,05	3.00	2.97	2.94	2.93	-1
	tan 6	44	64	135	257	312	305	280	250	222	202	203	210	186	.6-
"Epon" 828 "fiberglas" laminate, ϵ'/ϵ_0	€! / €	4.82	4.79	4.74	4.68	4.60	4.47	4.32	1 1 1	4.34	4.28	4.25	4.22	4.21	
curing agent $\mathrm{BF_{3} extst{-}400}^{\mathrm{c,d}}$	tan ô	46	41	69	124	171	182	168	1	135	131	131	148	192	
"Epon" X131 "fiberglas"	€' / €	5.46	5.42	5,38	5.27	5.24	5,06	4.84	1						
laminate, No. 51 ^c	tan 6	39	40	62	124	184	246	304							
IBIh. Miscellaneous plastics															
	ει /ε _ο	3.03	2,99	2,95	26.2	2.88	2,85	2,81		2.73	2.70	2.63			
	tan δ	112	86	82	43	86	124	170	1 1	196	155	112			
	€1/€	4.12	3.80	3.40	3.05	2.88	2.82	2.80	-	2.75	2.75	2,75			
	tan 6	444	999	748	513	233	107	71.5	1	62.0	09	52			
	e1/e	2.34	2.34	2.34	2,34	2.34	2.3								
	tan 6	9.1	9.7	7.0	5.9	10	10								

a. Houghton Labs. b. "Fiberglas" laminate (Minn. Mining). c. Shell. d. 181-"Volan" A cloth pressed at 125°C, cured at 330°F, 200 psi, post-cured 4 hours at 200°C; resin content 23.8%. e. Chlorinated polyether (Hercules). f. Lovell.

Values of tan δ are multiplied by 10^{-4} ; frequency given in c δ s.

		23	m	4	rc		7	· «		, G		σ	10	10	10
IB 2. Waxes (cont.)		1x10	1×10	1x10	1x10	1x10	1×10	1×10	3×10	1×10	3x10	8.6×10	1.4x10	2.4×10	5x10
Morse 280	€1/€	3.30	3.03	2.71	2.53		2.48								
	ťan ó	620	069	099	290	99	59								
Morse 300	€! /€	3.74	3.07	2.71	2.64	2.61	2.60								
	tan δ	1810	1030	490	189	83	46								
Morse 400	€¹ /€	2.88	2.74	2.68	2.62	2.58	2.52								
	tan 6	474	267	136	103	152	87								
Morse 6060-C	€¹ /€	2.18	2,17	2.15	2.14	2.11	2.11								
	tan 6	52	99	41	20	2	က								
Morse 6062	e1/e	2.31	2.31	2.31	2.31	2.28	2.25								
	tan 6	13.5	10	11	10	11	6								
I B 3. Miscellaneous organics											•				
"Missileon" ^a	€¹ / €	00.9	5,14	4.69	4.43	4.25	4.08	3.98	!		!	3.88			
	tan 6	1410	870	200	330	280	260	260	, ;		!!!	260			
"Rocketon" ^a	€¹ /€ 0	99.7	5.88	5.02	4.58	4.29	4.11	3,99		1 1	; ; ;	3.95			-17
	tan 6	2280	1500	860	540	360	320	350	[1 1	-	1 1	440			- · .
"Rocketon" (Modification 30)	e1/e	4.46	4.13	3.97	3.86	3.80	3.73	3.68	1	1	!	3,59			
	tan ô	774	430	223	163	125	124	142	1	1		220			
Irvington varnished linen tape	e1/e	1	!	!	4.22	1 .	2.58								
	tan 6	1	!	1	513	1	260								
"Scotch" tape No. 39	ει /ε ₀] 		!	!	3.34 (a	3.34 (at 3x10 ⁷)							
	tan 6	1		;	-	1 1	390 (a	390 (at 3x10 ⁷)							
Sealing Compound EC-612	E1/E	1	:	1	}		1	1	. 	1	17.4		-		
	tan 6		!!!!	; ; ;	!	1	; ; ;	1.	.	1	1140				
"Ferrotron" 119 (core)	e'/e	31,8	29.1	27.9	27.2	8.92	26.3	25.2	!!!	24	24	24	20		
	tan 6 _d	1130	460	230	160	130	144	150	† 	<200	<200	<1500	<1000		
	η, η		7.10	7.10	7.10	7,10	66.9	6.2	1	6.28	4.60	1.96	0.98		
	tan 6 m	1	-	1 1	1	10	20	65	1 1	3000	0019	14,500	20,600		
a. Haveg. b. Minnesota Mining.	c. Polymer Corp.	mer C	orp.		,					. •					

Values of tan δ are multiplied by 10^{-2} ; frequency given in c/s	
values of tan δ are multiplied by 10^{-2} ; frequency given in	/s
Talues of tan 6 are multiplied by 10"; frequency given	C
values of tan δ are multiplied by 10^{-2} ; frequency give	-
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2.4×10 ¹⁰	6.3	150	0.84	8400	11	140	0.44	24,000																		
1.4x10 ¹⁰	-	:	:	:		! ! !	•																			
8. 6×10	*0.8	130	1.19	* 0068	15	<1000	1.60	12,900															2.30	*	2.26	*068
3×10^9	-	!!!!	1 1 1	!	15	<500	3.56	5300															2.51	420	2.50	870
1x10 ⁹	1	; ;	3.4	2400	15	120	4.93	3000															2.54	150	2.63	470
3x108	-	-	!		-	1	1	}															2.54	44	2,65	190
1×108		-	3.6	300	15	61	5.4	350															2,55	14	2.68	20
$\frac{1\times10^{7}}{}$	14.8	80	4.7	80	15	29	5,65	<200															2.55	1.3	2.69	2
1x10 ⁶	15.0	98	4.7	20	15.1	34	5.54	< 20	4.0	300	3.5	250	3.2	28	2.8	14							2.55	<0.3	2.69	0.7
1×10 ⁵	15.2	90	4.7	-	15.1	28	!	!	!	!	1	;	-	!	-	!							2.55	<0.3	2.69	< T
1×10^{4}	15.3	130	4.7		15.5	108	1	1 1	!	! !	-	-	\$:	!								2.55	<0.3	2.69	<0.3
1×10^{3}	15.5	300	4.7	;	15.5	250	!	1	4.5	300	3.9	360	3,3	82	2.8	42			1.45	< 2			2.55	0.2	2.69	0.2
$\frac{1\times10^2}{1}$	16.5	460	1	-	15.8	380	1 1	1	!	-	!		1		-	;			:	!			2.55	1.4	2,69	2.2
	e' /e	tan 6 _d	μ' /μ	tan 6 m	ει /ε	tan b	μ' /μ ο	tan 6 -	ει /ε ₀	tan δ	ε' /ε ₀	tan 6	ει /ε _ο	tan 6	ε ¹ /ε	tan 6			e, /e	tan 6			€'/€ ₀ 2.55	tan 6	e1/e	tan 6
IB 3. Miscellaneous organics (cont.)	"Ferrotron" $308 \text{ (rod)}^{\text{a}}$				"Ferrotron" 309 (tape) ^a				npregnated Kraft		Varnished glass cloth ^c		Silicone varnished glass cloth,	flexible	rnished glass cloth,	stiff ^{c,d}	I C. Liquids	1. Inorganic	Nitrogen -1950 ^e		2. Organic	a. Aliphatic	"Kel-F" Alkane 464		"Kel-F" Alkane 695 ^g	

a. Polymer Corp.
 b. ASTM type A paper (D 1305), vacuum-impregnated with Sterling M50 (Sperry test sample).
 c. Sperry test sample.
 d. R-63 varnish (Union Carbide and Carbon).
 e. Cryogenic Eng. Lab, M.I.T. f. Chlorotrifluoroethylene dimer (Kellogg).
 g. Ibid., trimer.
 *Freq = 9.5 x 10⁹

Values of tan δ are multiplied by 10; frequency given in c/s.

I C. Liquids (cont.))			•						
2. Organic a. Aliphatic		1×10^2	1×10^3	$\frac{1\times10^4}{1}$	1×10^{5}	1×10^{6}	1×10^{7}	$\frac{1\times10^8}{1}$	$\frac{3\times10^8}{}$	$\frac{1 \times 10^9}{1}$	$\frac{3\times10^9}{}$	8. 6x10 ⁹	1.4x1010	$\frac{2.4 \times 10^{10}}{}$	5×10^{10}
"KEL-F" Alkane 8126 ^a	e' /e	2.88	2.88	2.88	2.88		2,88	2.87	2.80	2.61	2.37	2.16			
	tan 6	1.5	0.15	<0.1	<0.4	2.8	28	275	029	1080	066	684	-		
"KEL-F" Alkane 10157 ^b	e¹ /e,	2.88	2.88	2.88	2.88	2.88	2.88	2.70	1 1 1	2,39	2.28	2.23			
	tan 6	<0.2	<0.1	0.1	1.0	9.6	96	710	1 1	780	480	335			
"KEL-F" Alkane 12188 ^c	e¹/e,	2,94	2.94	2.94	2.94	2.94	2.90			2,33	2.24	2.23			
	tan 6	<0.2	<0.1	9.0	5.7	55	250	1 !	!	485	330	218	4		
d Hexane	e, /e	1 1	1	1.84											
	tan 6		1	۸ 1											
b. Aromatic										-					
OS-45 ^e	e, /e	2.65	2.65	2,65	2.65	2.65	2.64	2.63	!	2.48					
	tan 6	3400	336	34	21	42	41	130		482					
OS-59, tetra alkyl silicate	€1/€ 2.46	2.46	2.46	2.46	2.46	2,46	2,46	2.46		2.41	2.33	2.24			
ester	tan 6	12.4	1.3	0.2	<0.3	<0.6	2	50	:	324	410	380			-19
onoisopropyl biphenyl	ε, /ε ₀	2.61	2.61	2.61	2.61	2.61	2.61	2.60	2.57	2.52	2.51				-
	tan 6	150	15	1.5	9.0>	-	12	115	220	183	100				
Diisopropyl biphenyl	ε, /ε ₀	2,54	2,54	2.54	2.54	2.54	2.54	2.53	2.49	2.44	2.41				
	tan 6	9	9.0	0.2	<0.4	1.9	19	135	190	120	99				
"Selectron" 5084 monomer	€¹/€	!	1 1	1 1 1		1	1 1	1 1		1		3.01			
	tan ô	1	!			1	 	!		1 1	!	410			
"Stypol" 16B monomer ^g	€1/€	1 1	! !	7.16	!	1	1 1		1	!	; ! !	3.02			
	tan 6		 	43	1		1 1	1 1 1]]]	t 	1 1	420			
c. Petroleum oil												*			
Jet fuel JP-4	e 1/e 0		† - - - -	:	-	-	1 .	1	!	!!!	1 1	2.04			
	tan 6	!	1 1	1	1	!!!	! !	1	1	1	!	30			

<sup>a. Chlorotrifluoroethylene tetrameter.
b. Ibid., pentamer.
c. Ibid., hexamer.
d. Phillips.
e. Monsanto (St. Louis).
f. Pittsburg-Corning.
g. Robertson.
* Freq = 9.5 x 10.</sup>

Values of $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

										,			
I C 2 d. Silicones	$\frac{1\times10^2}{}$	$\frac{1\times10^2}{1\times10^3}$	1×10^4	1×10^{5}	$\frac{1\times10^6}{}$	$\frac{1}{1 \times 10^{7}}$	$\frac{1\times10^8}{}$	3×10^{8}	$\frac{1\times10^9}{1\times10^9}$	3×10^9	$\frac{8.6 \times 10^9}{1.4 \times 10^{10}} 2.$	2.4×10^{10}	5×10^{10}
High Vacuum Grease	€¹/€°	!		1	1	!			!				
·	tan 6	!	-	;	-		1	1 1	1	80	200		
$^{ m DC}$ XF-6620 $^{ m a}$	$\epsilon^{i}/\epsilon_{o}$ 2.81	2.81	2.81	2.81	2.81	2.81	2.81	2.80	2,79	2.67	2.41		
	tan 6 3	0.3	<0.1	<0.1	<0.2	1.7	17	48	103	180	217		
I D. Gases													
Nitrogen 14.7 psi	€¹ / ﴿ وَ	1,00058	9028) 	-			1.	1.00058 1	1,00058			
	tan 6	-	< 1	-	-	-	-		< 10	< 10			
1000 psi	e'/e,	1.0403	0403	:	-	1	1 1 1	-	1.0403	1.0403			
	tan 6	:	< 1	;	:	1 1	!	1 1 1	< 10	< 10			
2000 psi	e'/e	1.0807	2080	:	-	-		-	1,0807	1.0807			
	tan 6	-	< 1		1 1	:	}	1	< 10	< 10			
3000 psi	e'/e,	1 1	1.210	:	f 1 1		1	!	1.210	1.210			
	tan 6	!	< 1		1	1	-	1	< 10	< 10			-2
4000 psi	€¹/€°	1	.563	-	1	!	;	;	1.563	1.563			0-
	tan 6		^ 1	-	-	!		1	< 10	< 10			
5000 psi	e'/e,	1.	1.857	!	!	1	-	-	1.857	1.857			
c	tan 6		\ 1	-	!	!	1	;	< 10	< 10			
Nitrous oxide 14.7 psi	e'/e	1,0030	030	;	;	:	-		1.0030	1.0030			
	tan 6		< 1	1	}	!	;	}	< 10	< 10			

a. Dow-Corning. b. Purified (Air Reduction). c. Olin Mathieson.

II. SUPPLEMENT TO DATA AT ROOM TEMPERATURE A. Materials measured too late for inclusion in Section I

Values of $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

		1102	1.403	12104	1×105	1210	1×107	1×108	3x108	1x109	3x10 ⁹	8, 6x10
Ceramics		OIXI	TXTO	1410	777	2141						
"AFC" Alumina	€ / €	1	1 1	!	1 1 1	1	1	1	1	1 1	!!!	8.28
	tan 6	1 1 1	7	1	1	1 1	! ! !	!	1		1	9.4
"AlSiMag" 544 ^b	€1 / €	1	! ! !	1	!	!	!	-	}	!	† ! !	69.7
(Supercedes previous sample)	o tan ô	-	ł	}	;		!	1	. !	1 1	1 1 1	16
	€ا / و ّ	!	1	;		1	!	1 1 1		1	1	5.51
)	tan 6	1	;	! !		-	!		1 1	-	1 1	1.0
"AlSiMag" 602 (dried) ^c	€1/€		!	1	;	1 1	1	1	}	1	£ ! !	4.62
	tan 6	-	1	!		-	1 1	1	1 1	!	1 1 1 1	18
"AISiMag" 652 ^b	€1/€	9.21	9.19	9.18	9.18	9.18	9.18	9,18				
	tan 6	74	11.5	4.2	8	8.0	0.15	×				
Beryllium oxide, hot pressed	e! / e	5.58	5.57	5.55	5.54	5.54	5.54	5.54		1	1 1 1	5.62
(d = 2.560 gm/cc)	o tan 6	110	34*	*.co	* ₀	1.8	1.3	1.8	1	1	!	10.4
Beryllium oxide, crucible grade	e' / e		}	† 1 1		1	1	. 1	! ! !	!!!	1 1	3,55
(d = 1.784 gm/cc)	tan 8	-	;		}	-	1	1	1	1	! ! !	14.9
Coors AI-200 (1956 production)	e' /e	1	ŧ ţ 1		}	;		1	! ! !		1	8,63
	tan 6		;		;	-	1		 	- I ! !	1 1	11.6
"Alite" AP-212 ^e	€1/€	1		!		1 5 1	1	. !		1	1	8.25
	tan 6	-	;			1		!	1			8.6
"Alite" AP-216 ^e	e1/e	1	}	:	-		1 1		;	!	1 1	8.03
	tan 6	1	1 .		!			1		1	1	13
"Alite" AP-312 ^e	€' /€	1	1	1	1 1 1	!	1	1	1	!	1 1	8.42
	tan 6			:	! !	1	1	1		!	!	11.5

a, Amer, Feldmuehle, b. Alumina (Amer, Lava). c. Lava (Amer, Lava). d. Beryllium Corp. e. Alumina (U.S. Stoneware). *Mottled sample d = 2.546.

II. SUPPLEMENT TO DATA AT ROOM TEMPERATURE (Cont.)
A. Materials measured too late for inclusion in Section I

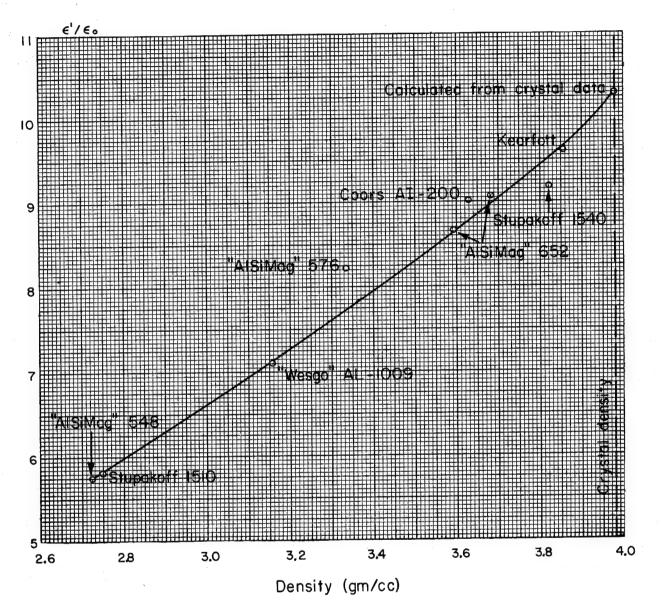
Values of tan δ are multiplied by 10 4 ; frequency given in c/s.

						•	•		•			
Plastics		$\frac{1\times10^{2}}{1}$	$\frac{1\times10^3}{1}$	$\frac{1 \times 10^4}{1 \times 10^4}$	$\frac{1\times10^5}{}$	1×10^{6}	$\frac{1\times10^{7}}{1}$	$\frac{1\times10^8}{}$	3×10 ⁸	1×10^9	$\frac{3\times10^9}{}$	8, 6x10 ⁹
"Markite" 3985	€1/€	-		-	-	-	!	1 1	!	:	!	40
	tan ô			*400	> 20*	> 10	* 09 <	!	1	-	-	3.0
	٣	(ohm-cm)	-	1.73	1.73	1.73	1.73		-		1	1.7
"Markite" 12812	e' /e	}	-		:	1	1200	-	1	-	1	21
	tan 6	!	-	>105*		!	n* ∧	-	1	1		1.5
	٣	(ohm-cm)	!	16.4	16.4	16.0	15.8	!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!	!	1 1	1 1 1	9.9
"Scotchply" 1002, isotropic	ει /ε ₀	-		1 1		1			4.56	4,53	4.51	4.48
	tan 6	1	}	1	1	8 1 1		-	158	162	167	175
"Scotchply" 1002, crossply	e1/e		1	1	:	1 1 1		1 1	4.42	4.40	4.39	4.38
	tan 6	!	;	-		!	!	!	164	177	186	200
"Scotchply" 1002, unidirectional ^a	1 e1/e	!	1	!	-	-	1	1 1	4,35	4.32	4.28	4.24
	tan 6	-		!		!	1	1	171	171	172	173
"Scotchply" XPM-107 ^D	e' /e		-		1 1	!		!	4,31	4,30	4.29	4.28
	tan 6	;	:	:	1	1	1	-	129	162	181	202

a. Polyester "fiberglas" laminate (Minn. Mining) b. Epoxy - "fiberglas" laminate (Minn. Mining). * tan δ not mulitplied by 10^4 .

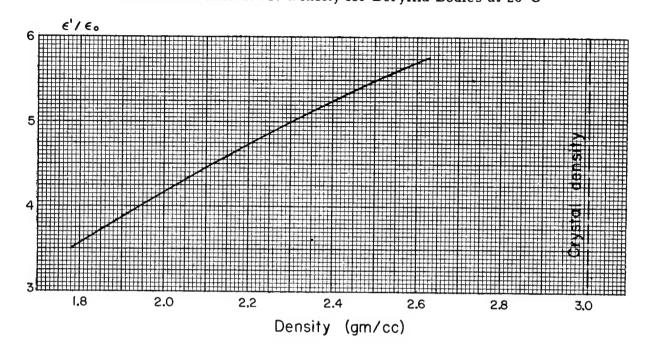
II B.

Dielectric Constant vs. Density for High Alumina Bodies at 26°C

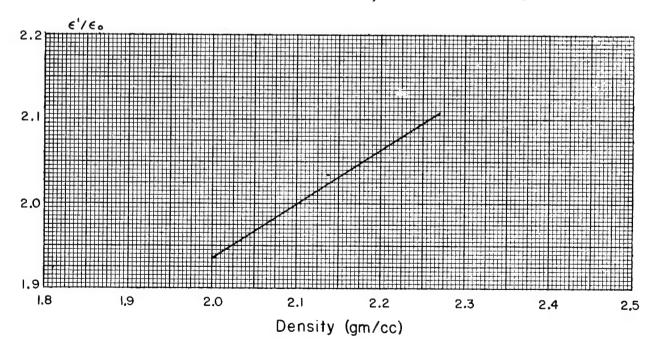


II B.

Dielectric Constant vs. Density for Beryllia Bodies at 26°C



Dielectric Constant vs. Density for "Teflon" at 26°C



III. Data at Fixed Frequencies as a Function of Temperature

Previous to this volume of the "Tables," the highest temperature of measurements has not exceeded, with few exceptions, the long-time thermal stability temperature for each material.

In the present volume, data have been taken on several laminates at temperatures above normal, For these, the time intervals of measurement are indicated. The samples were measured in partial vacuum in order to withdraw gaseous decomposition products.

Other curves showing data with increasing and decreasing temperatures, particularly with ceramics, indicate changes due to water loss since the sample is not in equilibrium with room humidity at the end of the run. The change in electrical properties with water loss is a reversible process more easily demonstrated in the microwave region, where it is mainly a volume effect, than at low frequencies where it is mainly a surface effect.

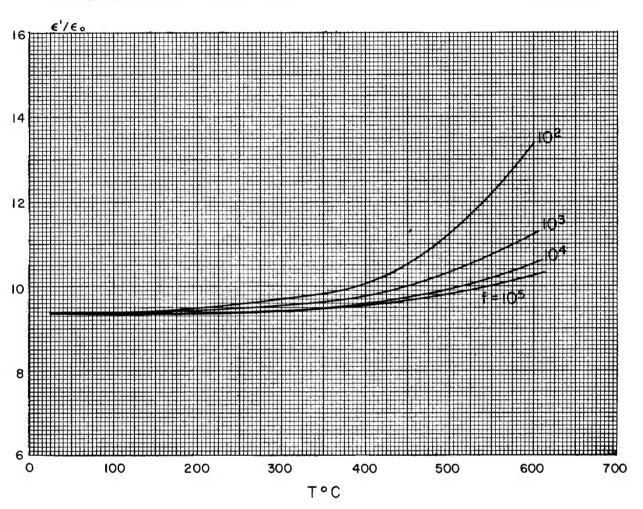
As in the room temperature measurements, the electric field direction is perpendicular to the plane of laminates for frequencies in the range 10^2 through 3×10^8 c/s; it is parallel to or in the plane of the laminate for all higher frequencies unless otherwise specified.

The measuring frequency for the curves marked $f = 10^{10}$ was 8.5 kMc.

III A 1. Crystals

Aluminum oxide crystal, sapphire Field perpendicular to optical axis

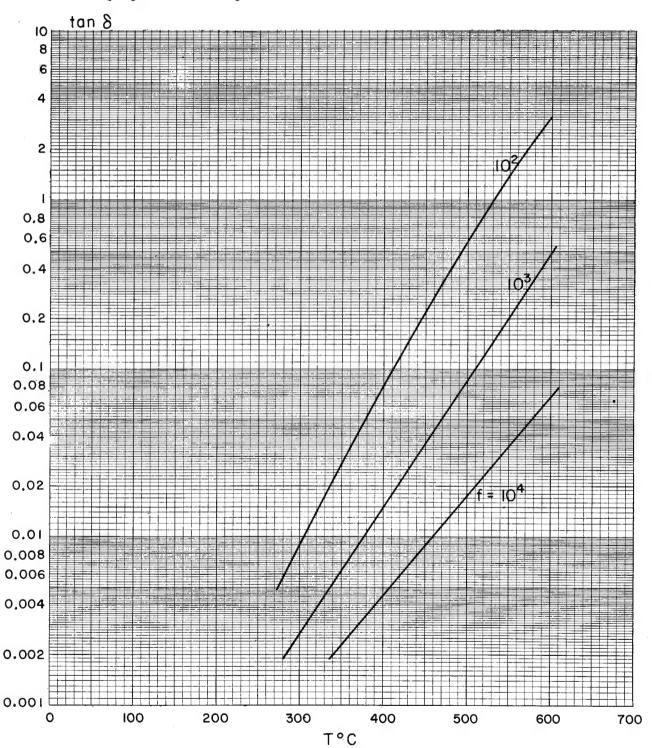
Linde Air



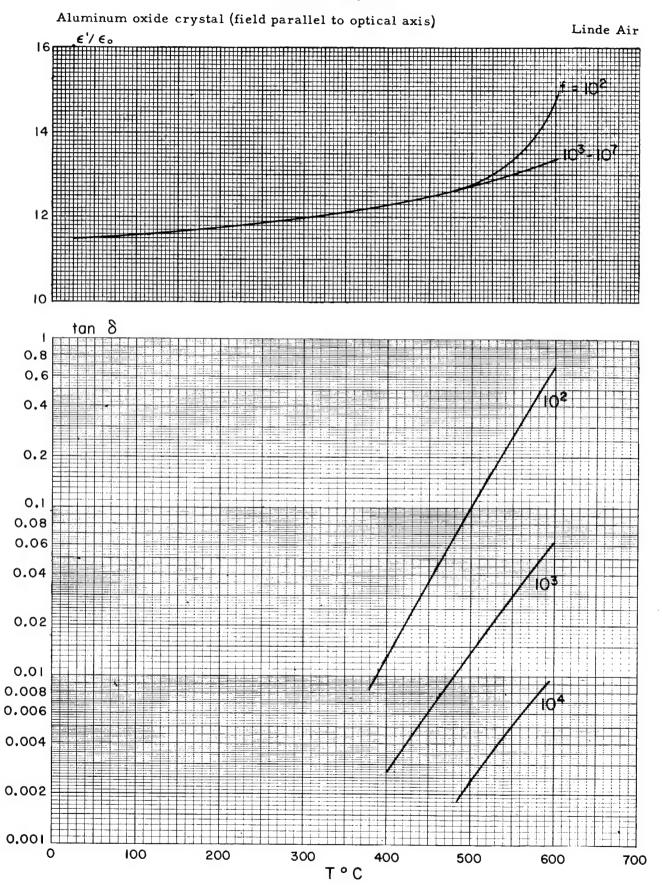
III A 1. Crystals

Aluminum oxide crystal, sapphire Field perpendicular to optical axis

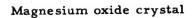
Linde Air



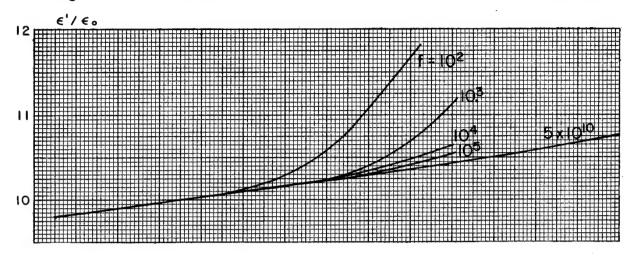
III A 1. Crystals

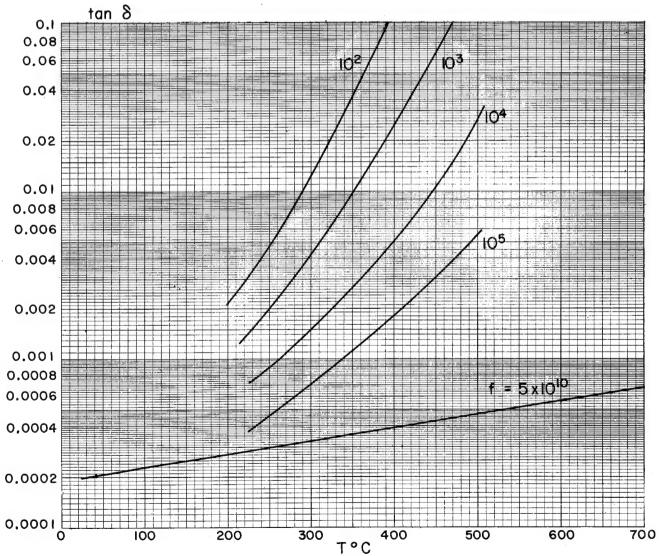


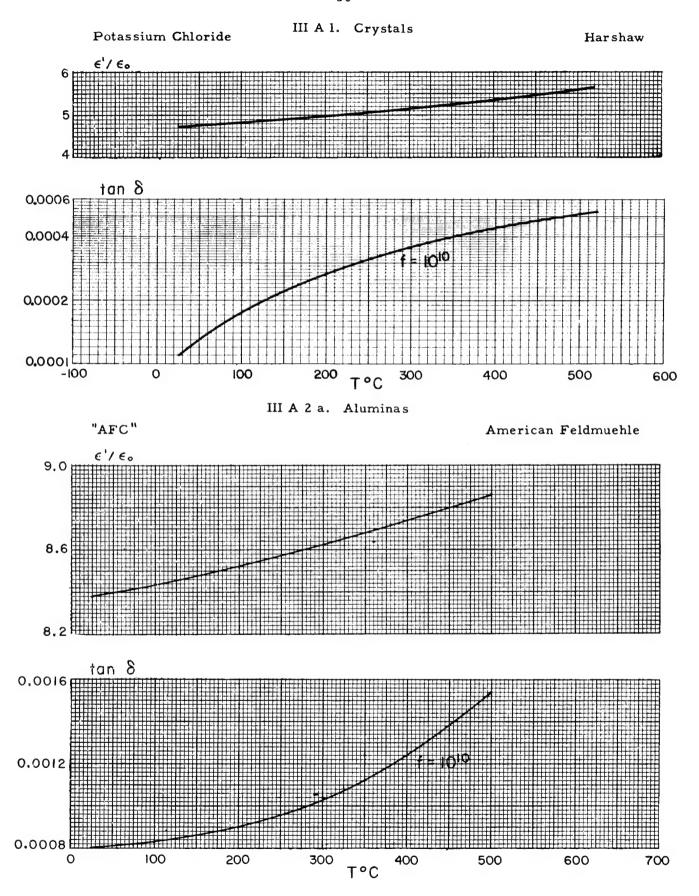
III A 1. Crystals



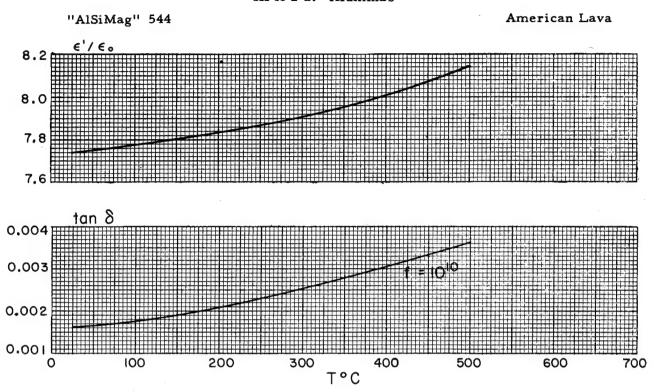
Norton

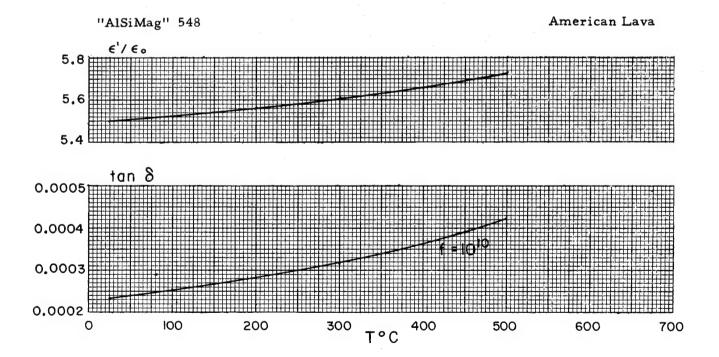




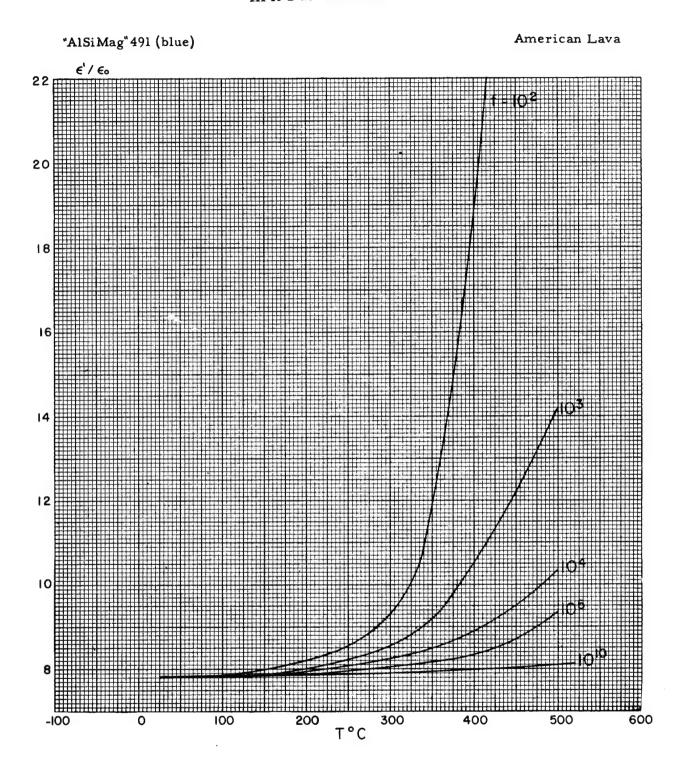


III A 2 a. Aluminas

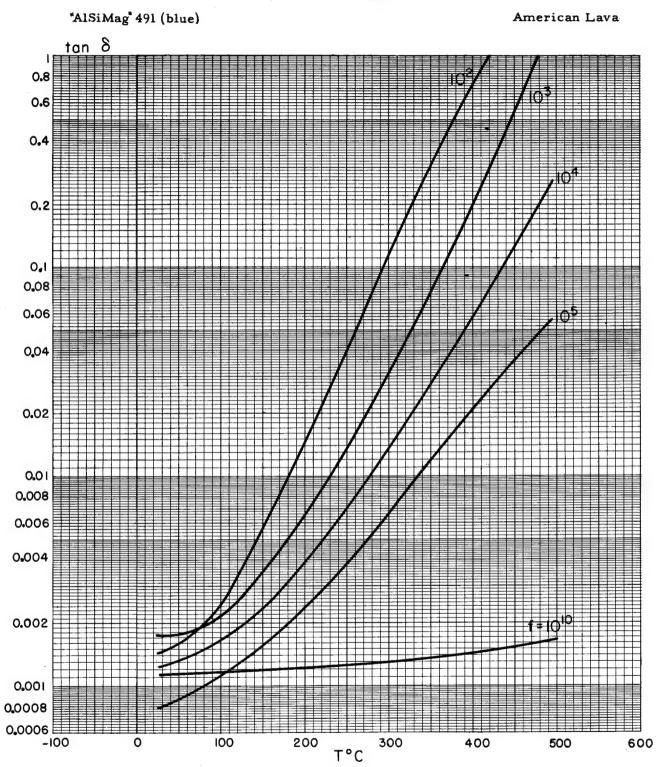




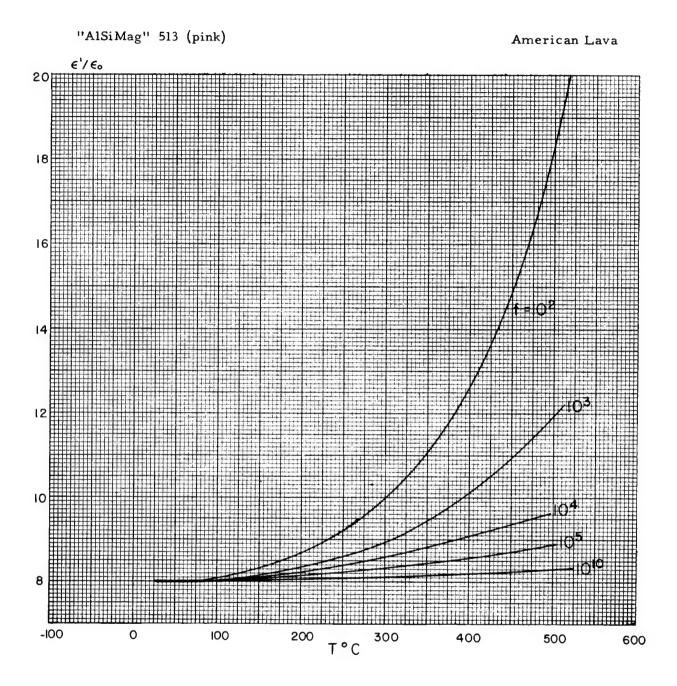
III A 2 a. Aluminas



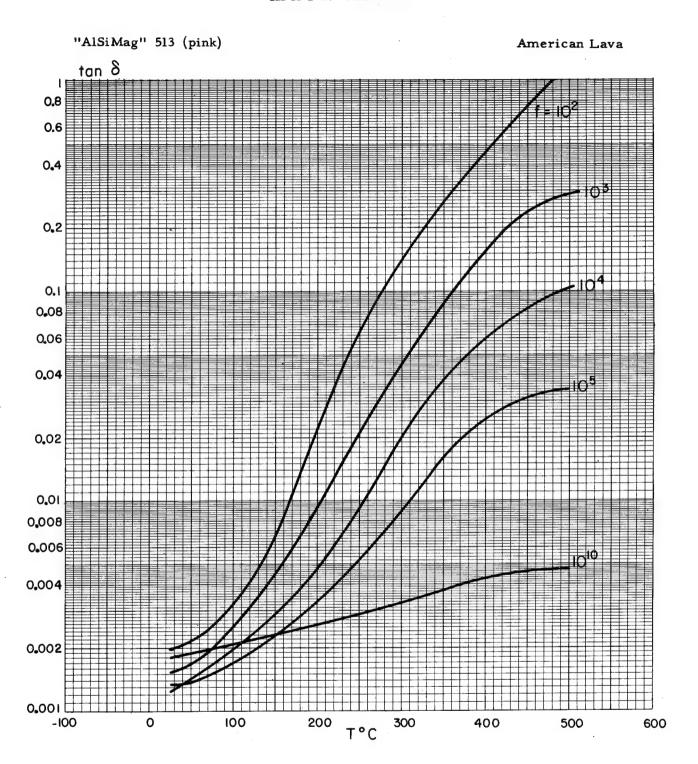
III A 2 a. Aluminas



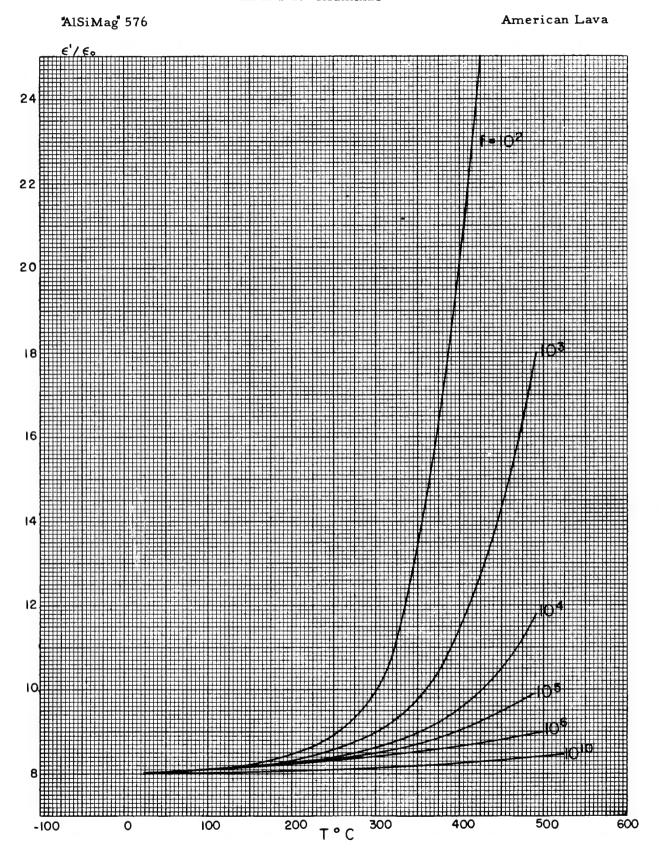
III A 2 a. Aluminas



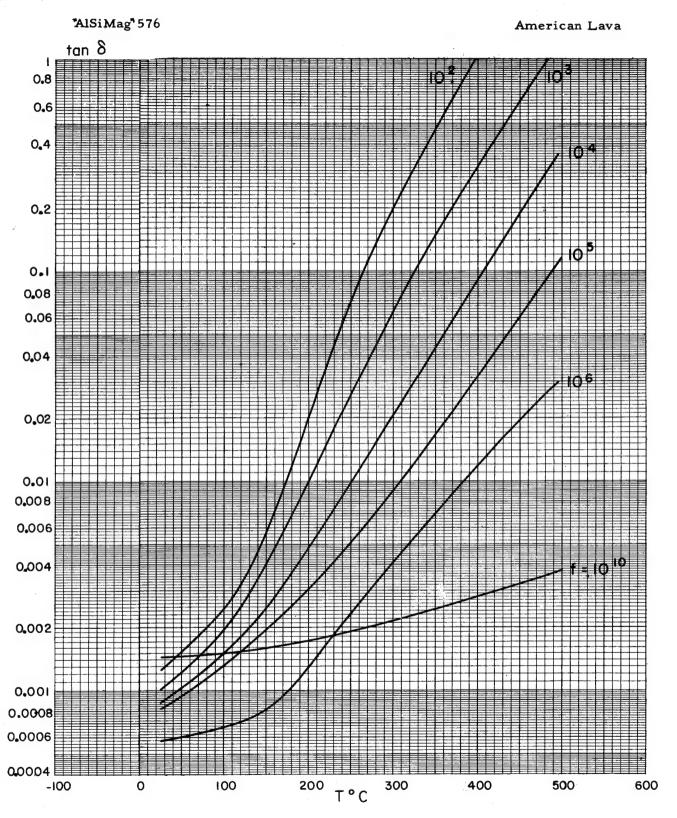
III A 2 a. Aluminas



III A 2 a. Aluminas



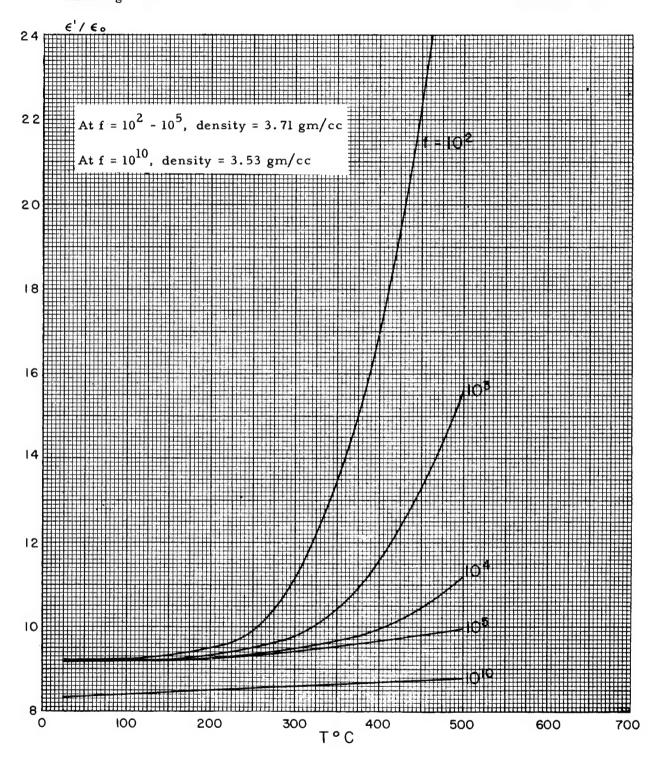
III A 2 a. Aluminas



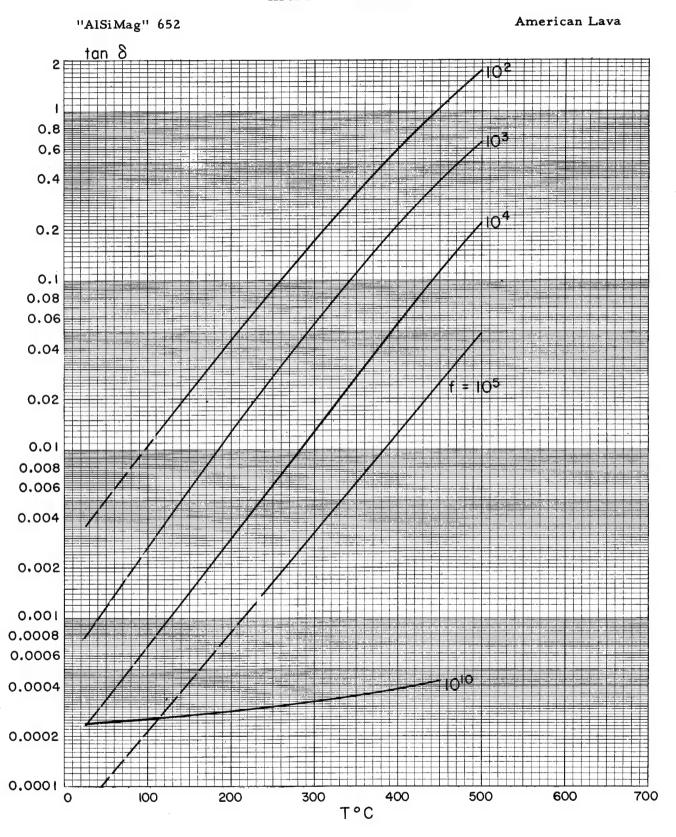
III A 2 a Aluminas

"AlSiMag" 652

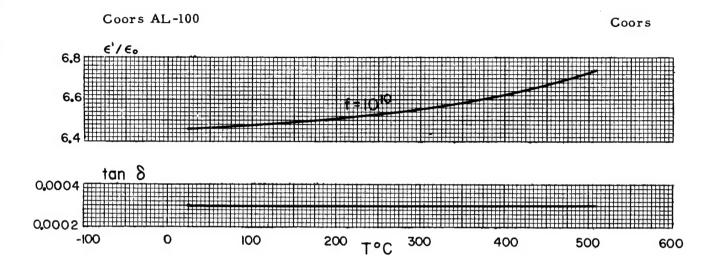
American Lava

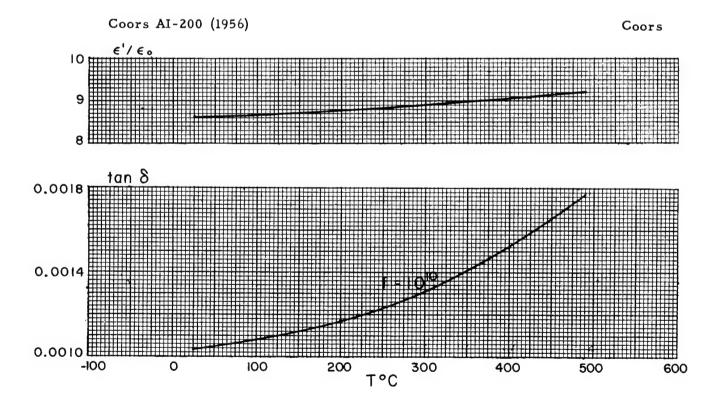


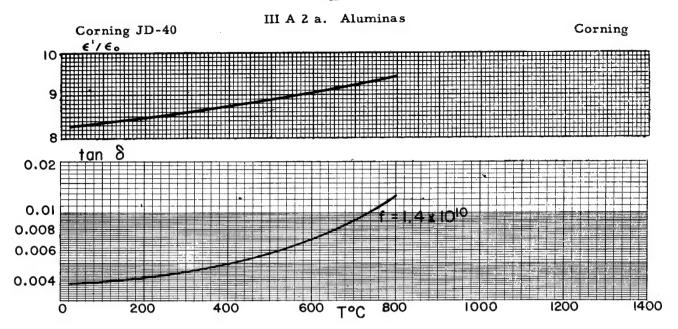
III A 2 a. Aluminas

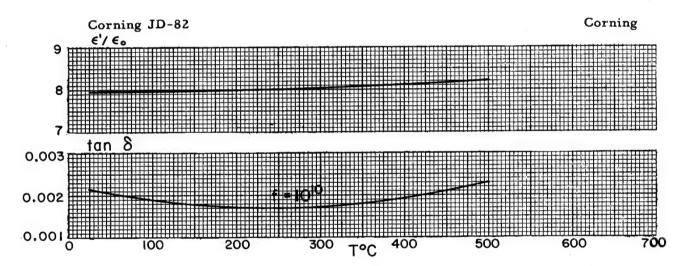


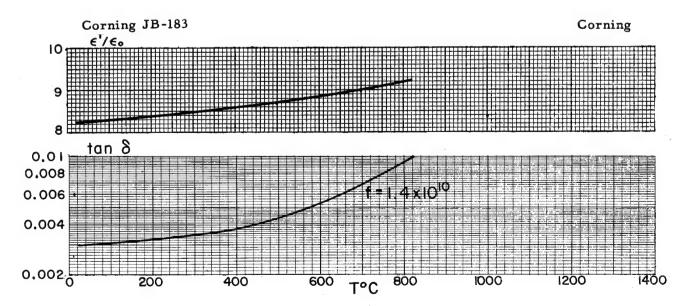
III A 2 a. Aluminas



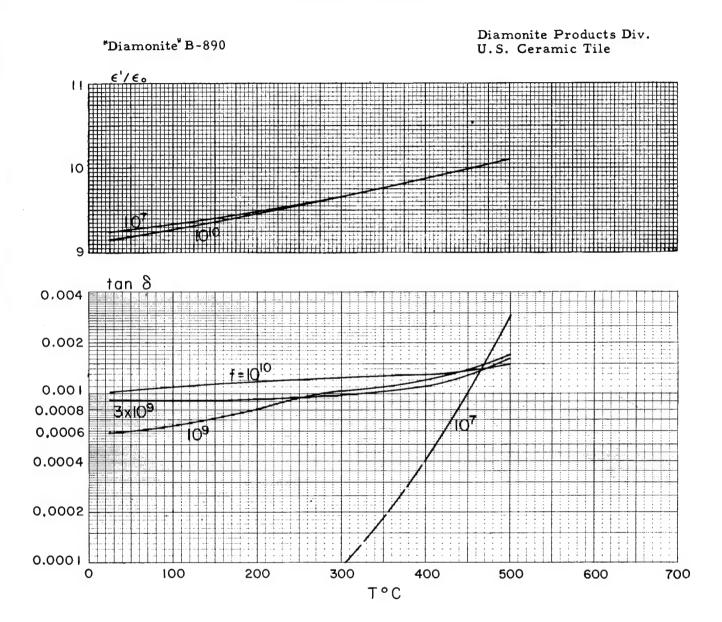




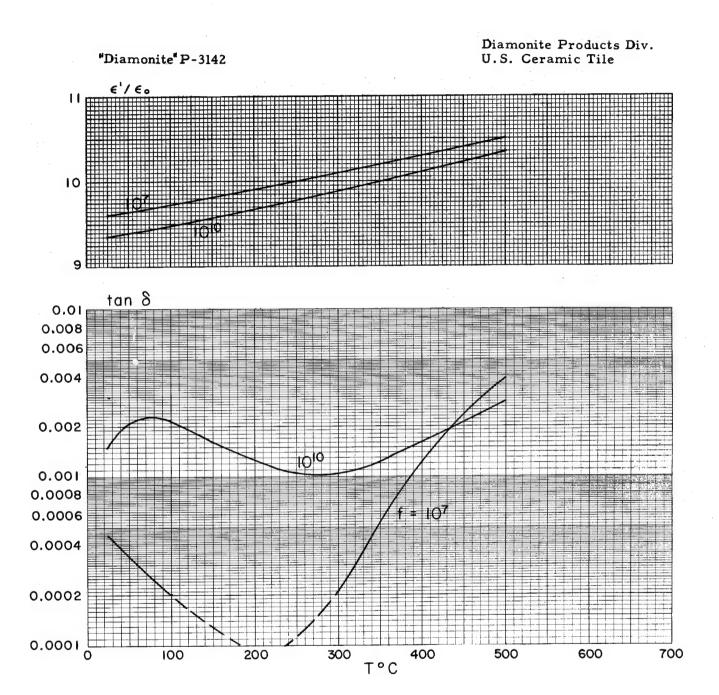




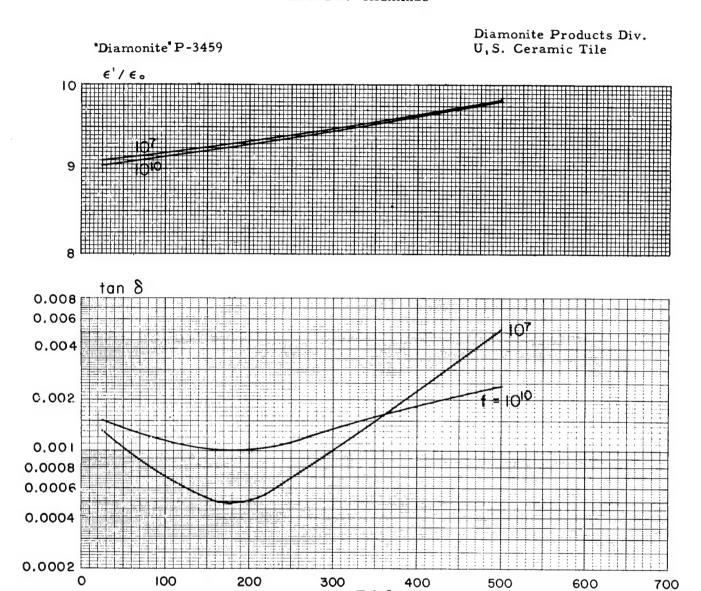
III A 2 a. Aluminas



III A 2 a. Aluminas

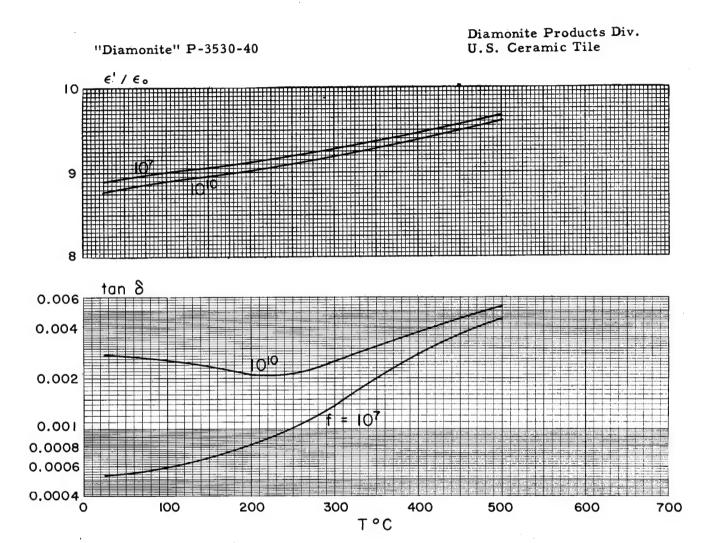


III A 2 a. Aluminas

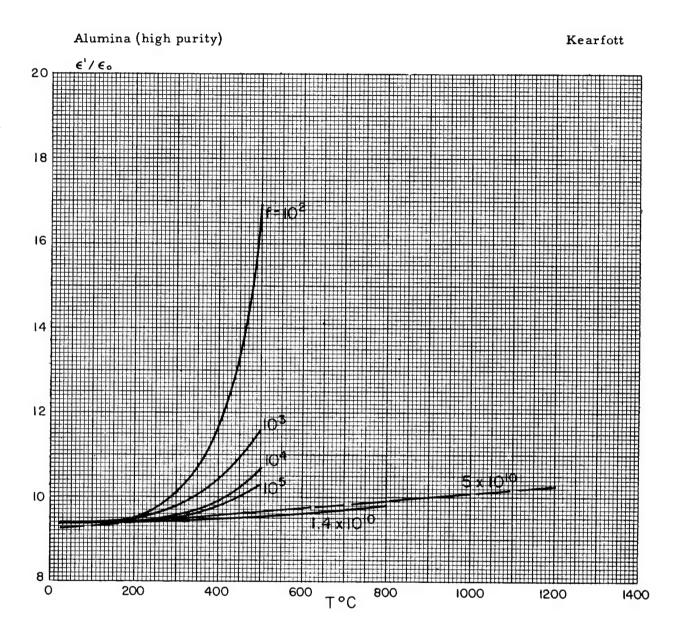


T°C

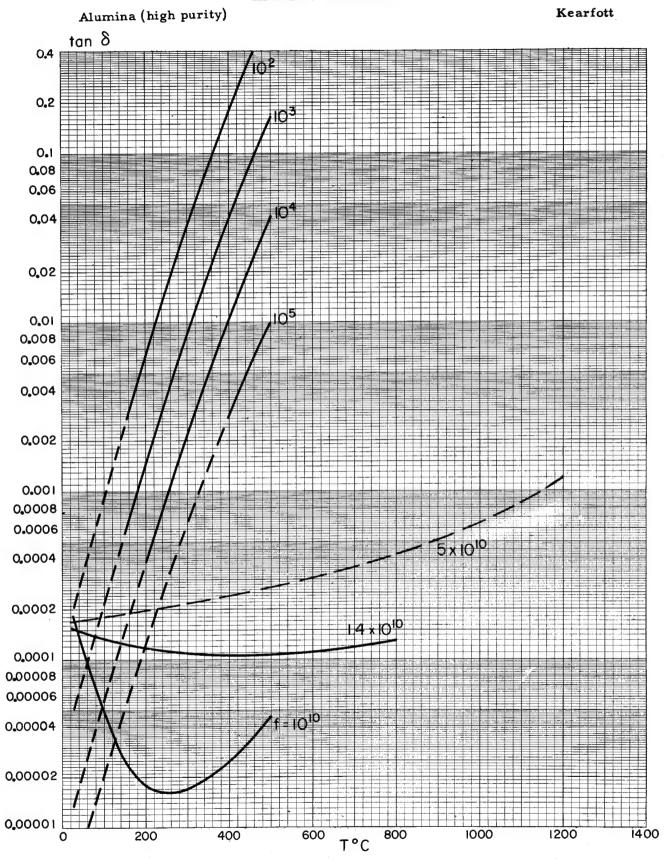
III A 2 a. Aluminas



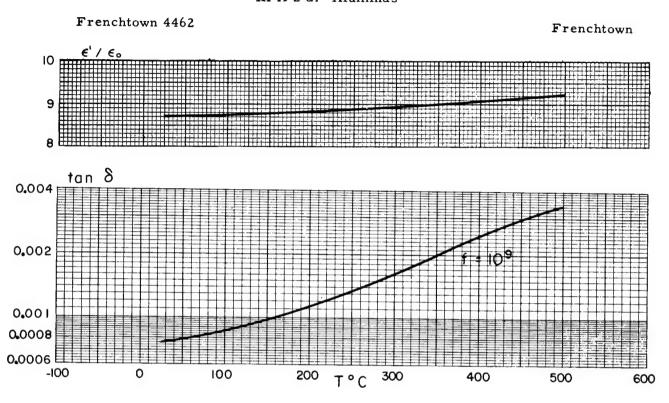
III A 2 a. Aluminas

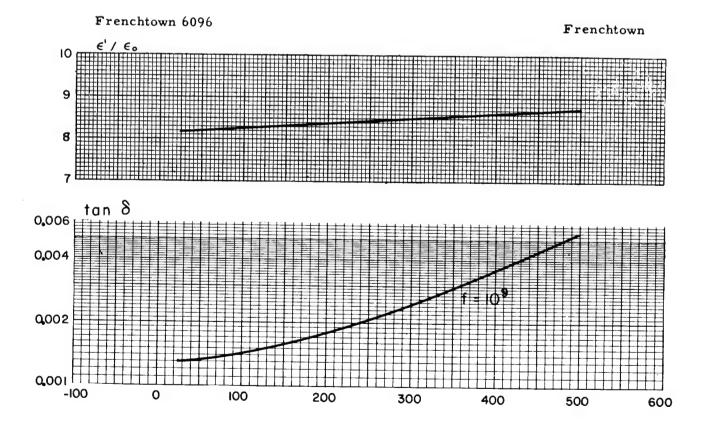


III A 2 a. Aluminas

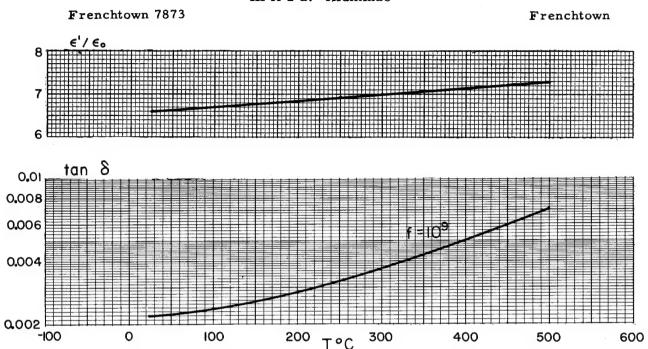


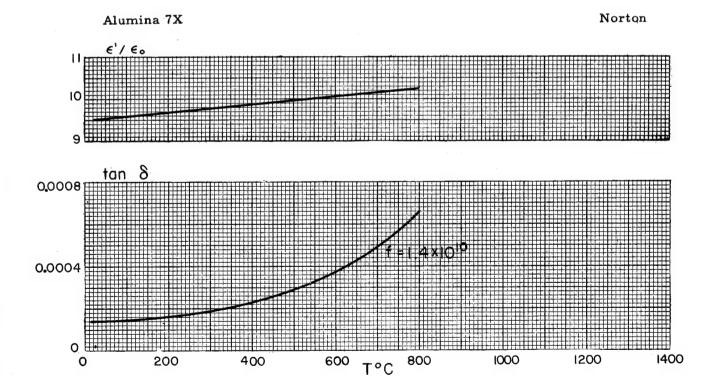
III A 2 a. Aluminas



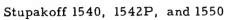


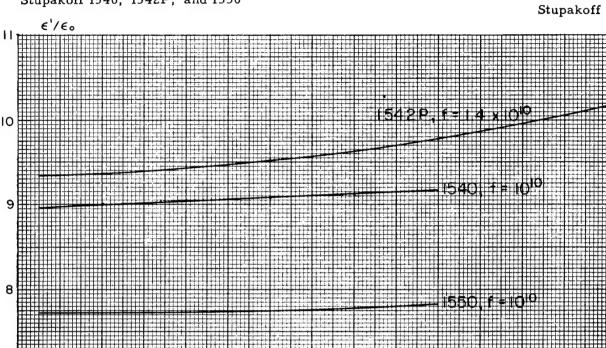
III A 2 a. Aluminas

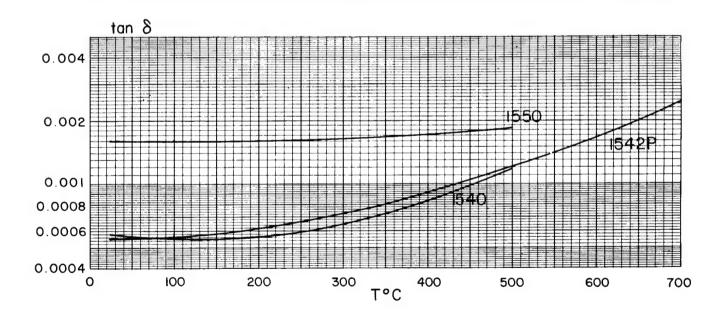




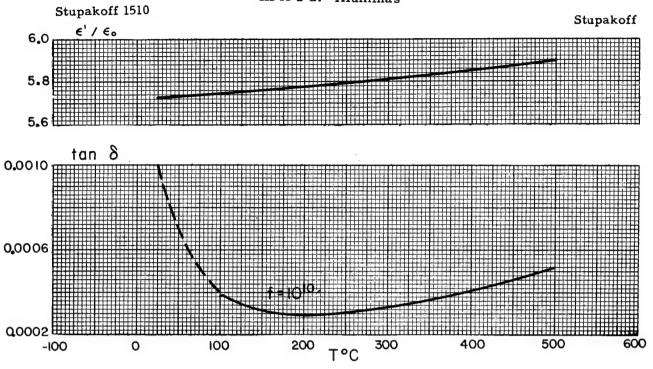
III A 2 a. Aluminas

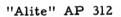




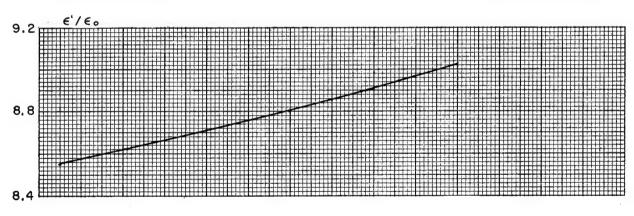


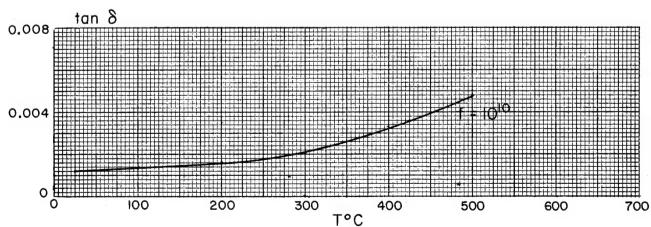
III A 2 a. Aluminas

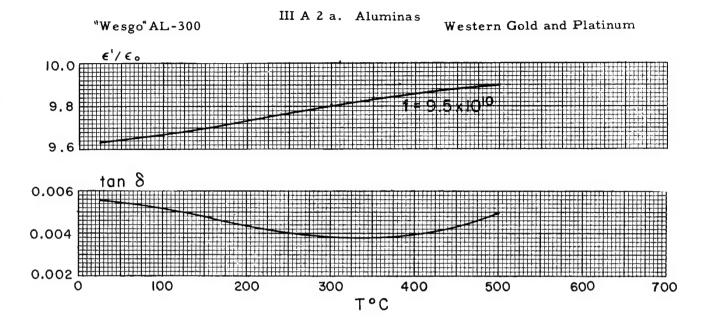




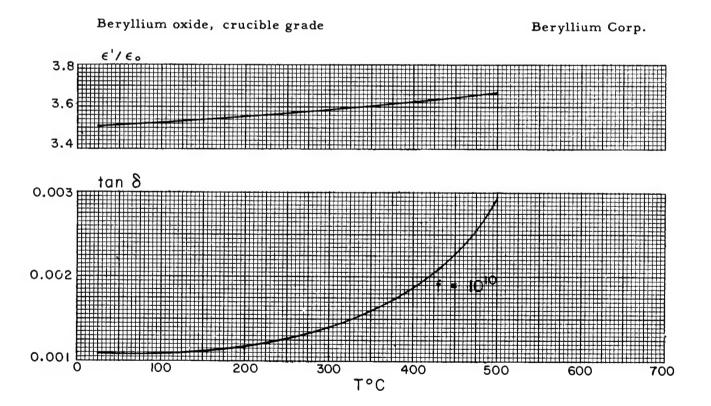
U.S. Stoneware







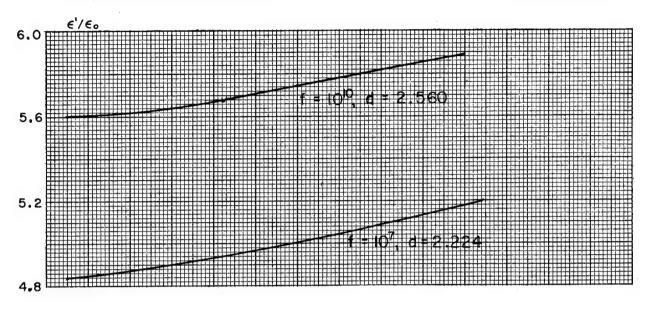
III A 2 b. Beryllias

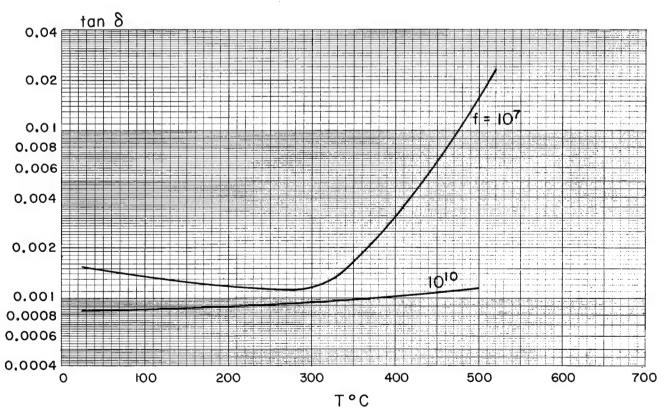


III A 2 b. Beryllias

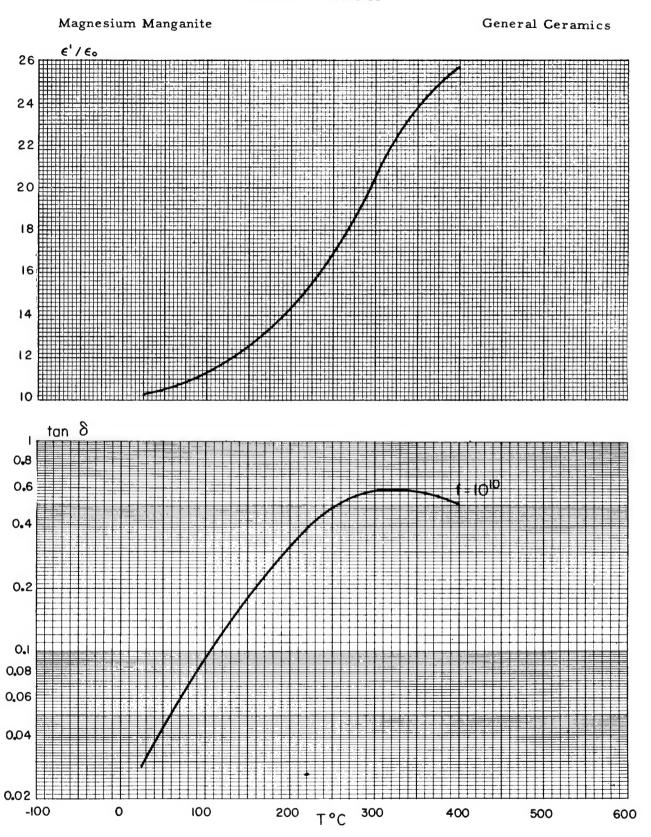
Beryllium oxide, hot pressed

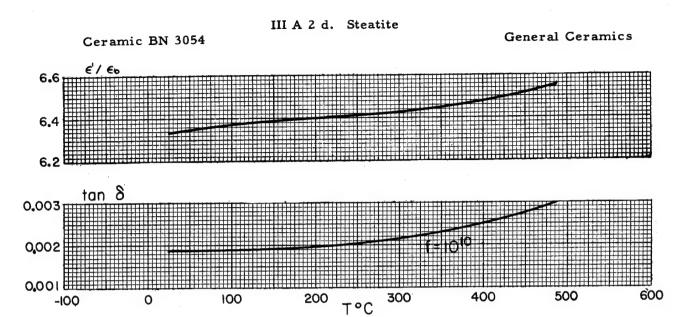
Beryllium Corp.

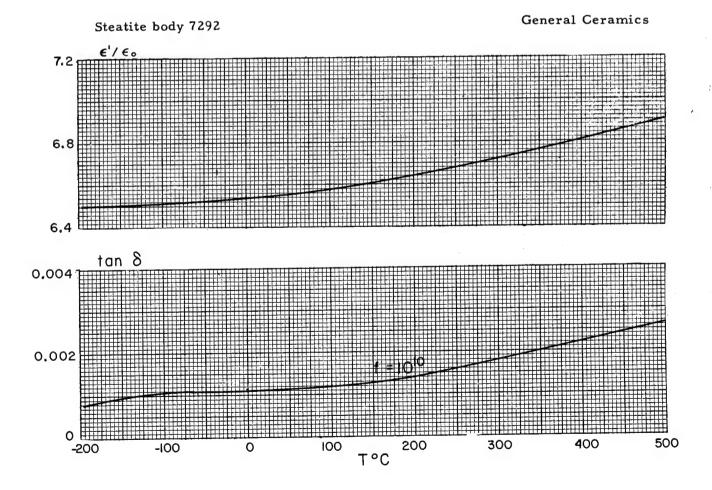




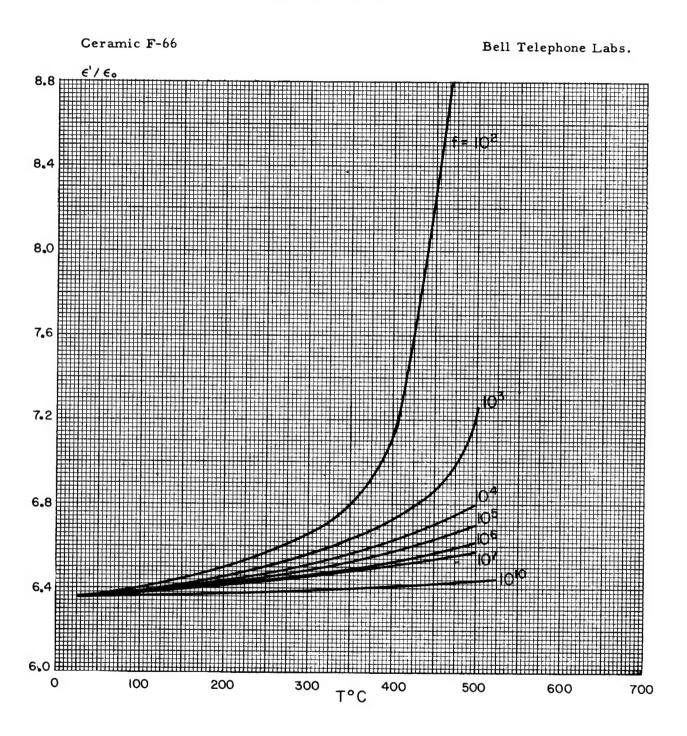
III A 2 c. Ferrites



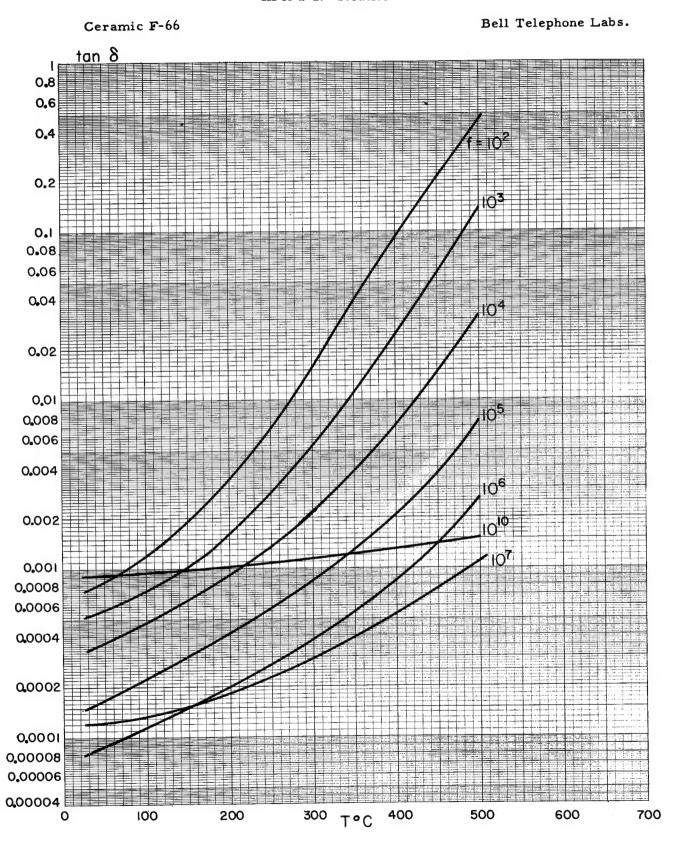




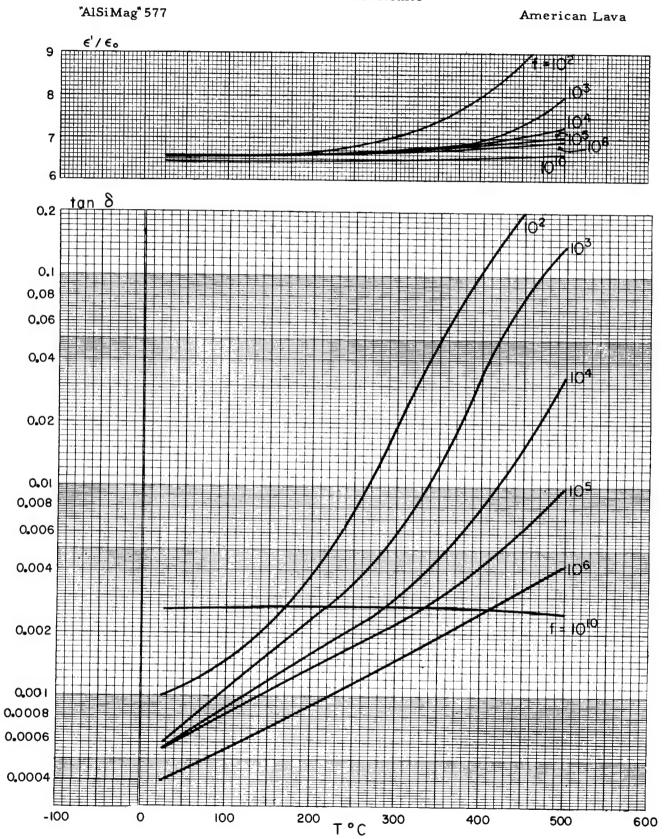
III A 2 d. Steatite



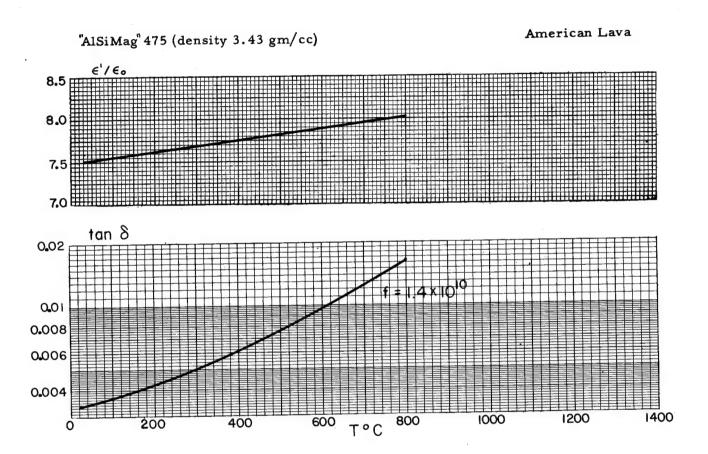
III A 2 d. Steatite



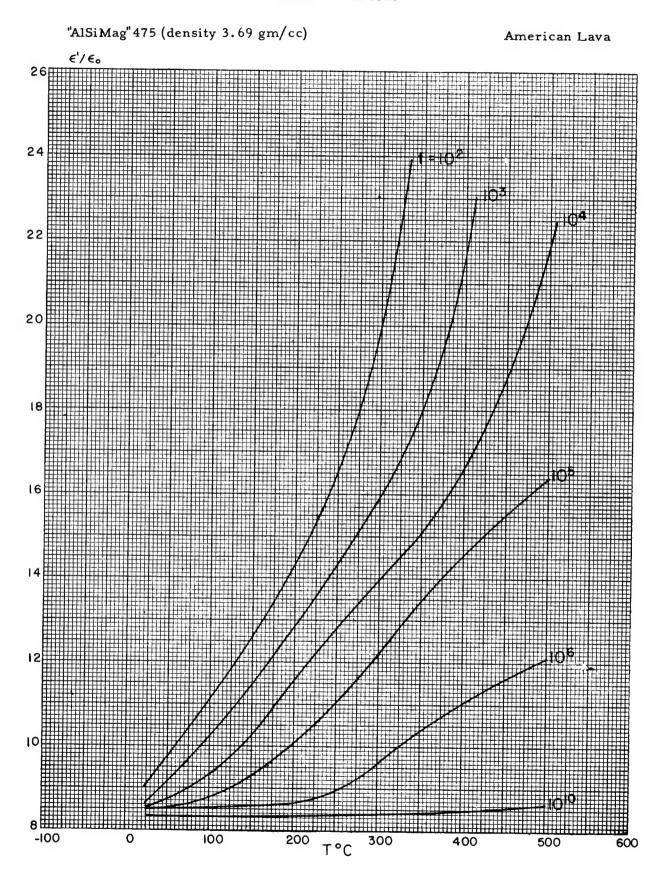
III A 2 e. Wollastonite



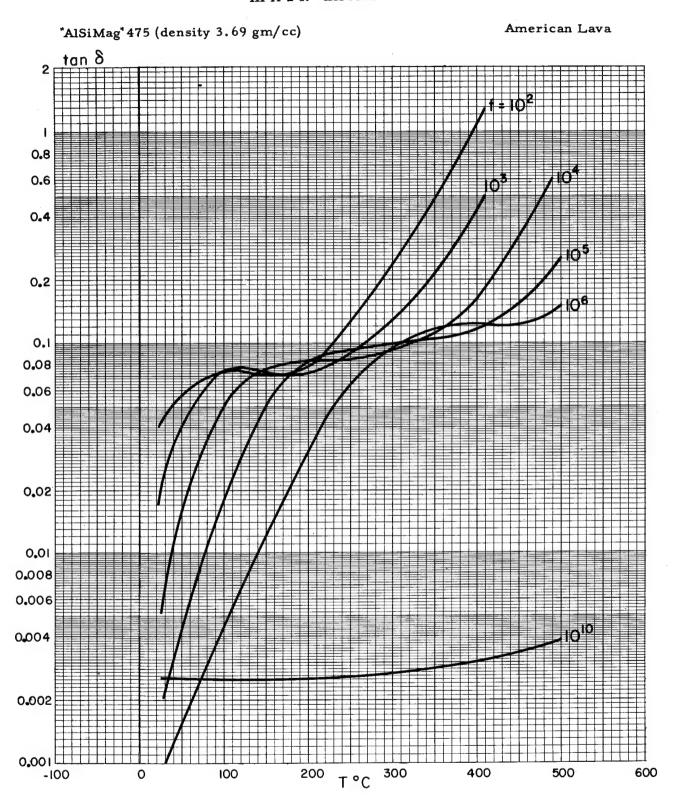
III A 2 f. Zircons



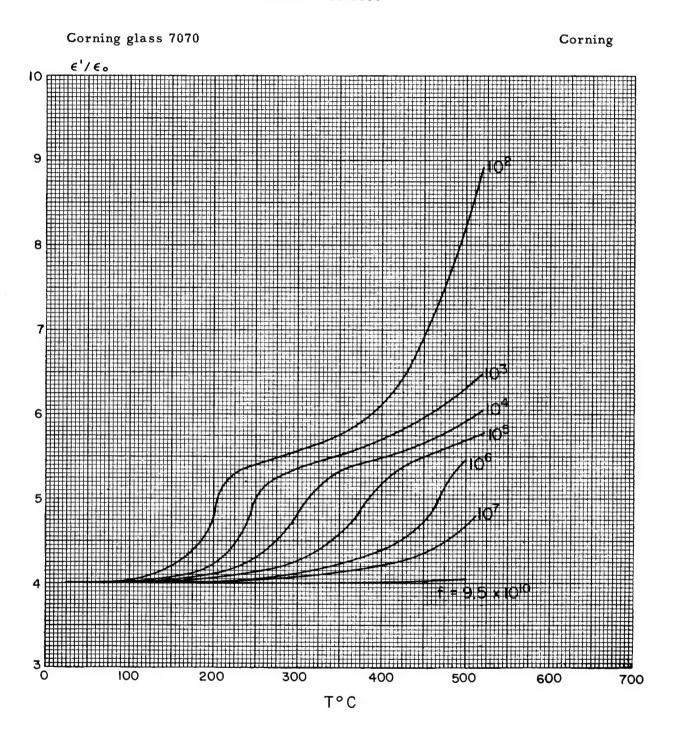
III A 2 f. Zircons



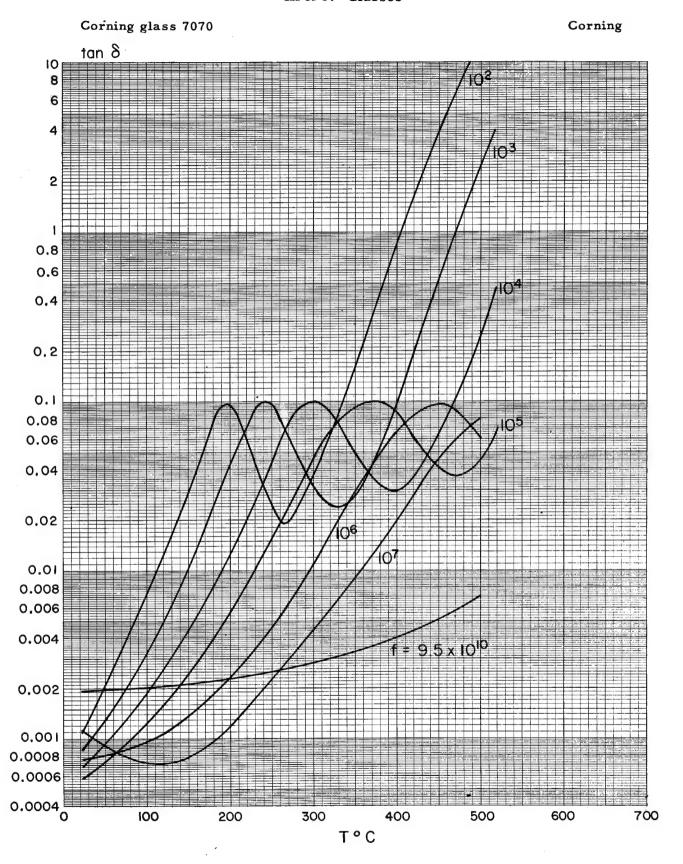
III A 2 f. Zircons



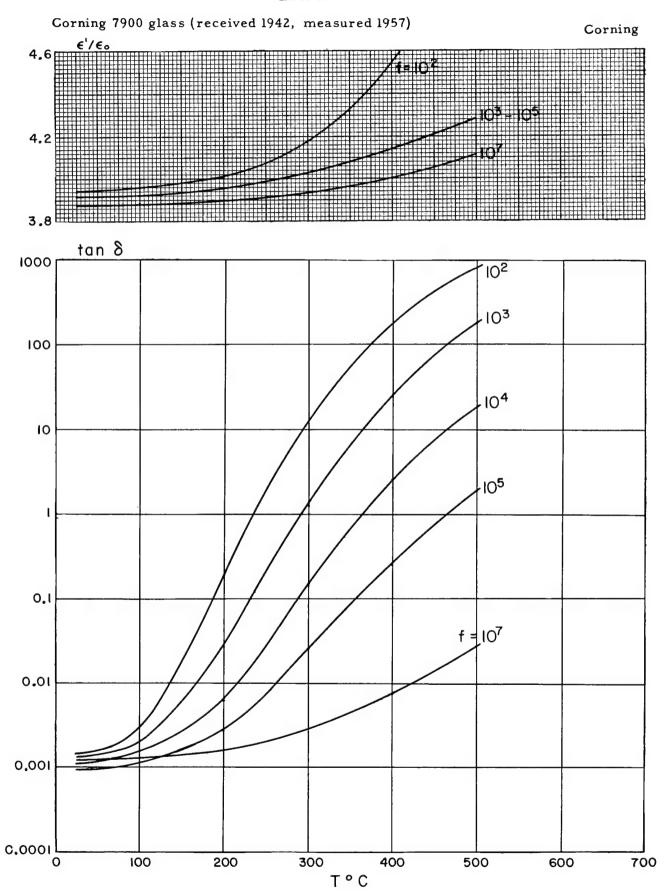
III A 3. Glasses



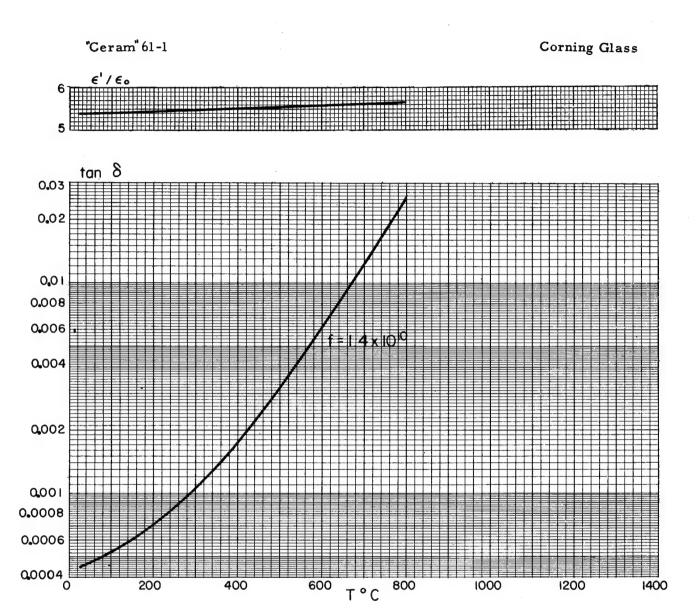
III A 3. Glasses



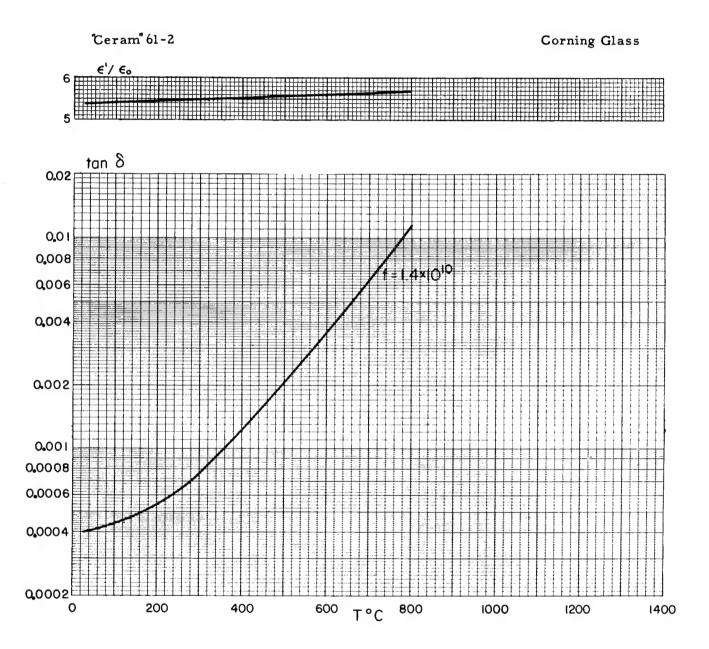
- 64 -III A 3. Glasses



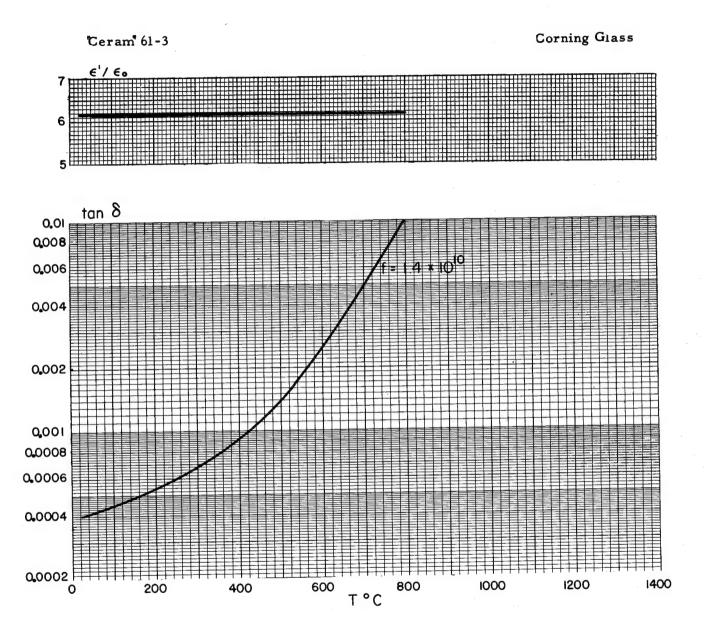
III A 3. Glasses



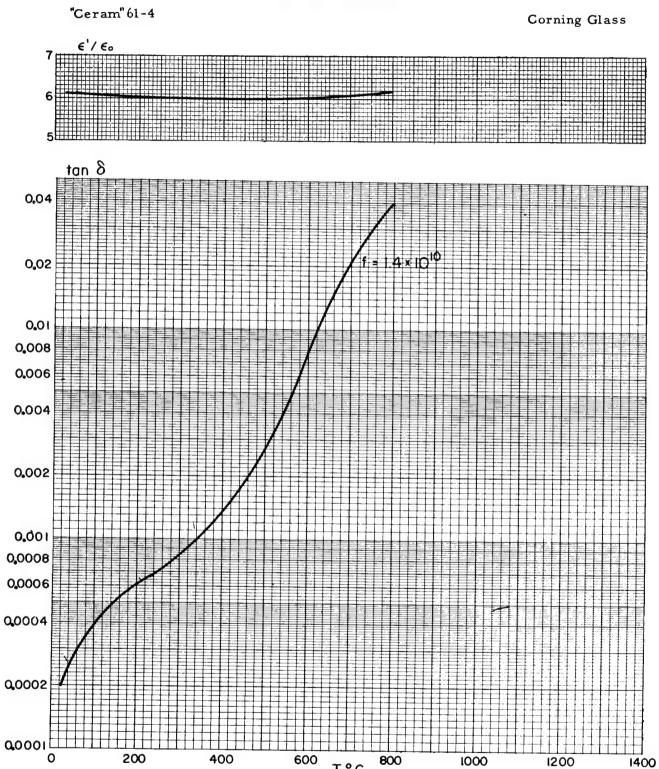
III A 3. Glasses



III A 3. Glasses



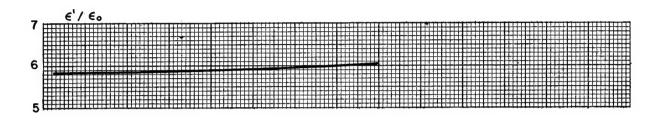
III A 3. Glasses

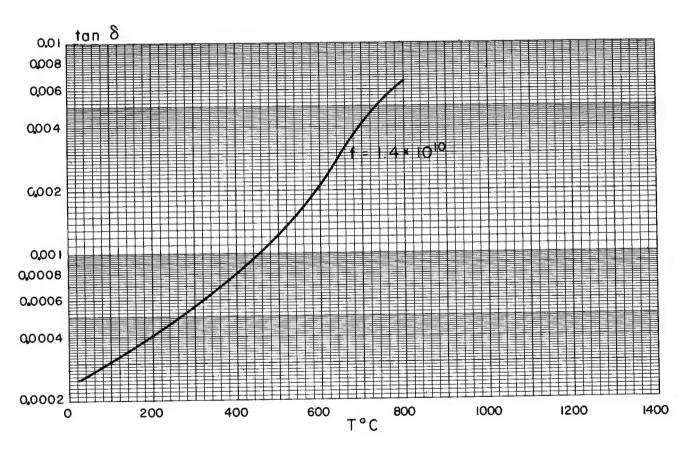


III A 3. Glasses

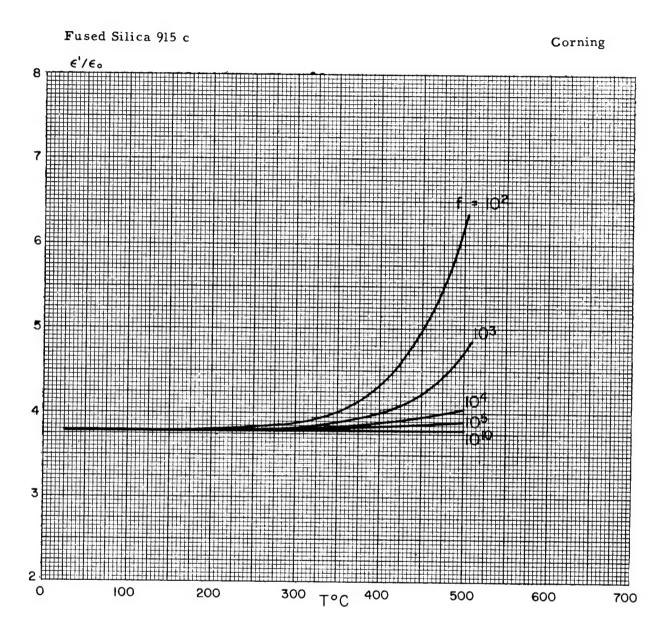


Corning Glass

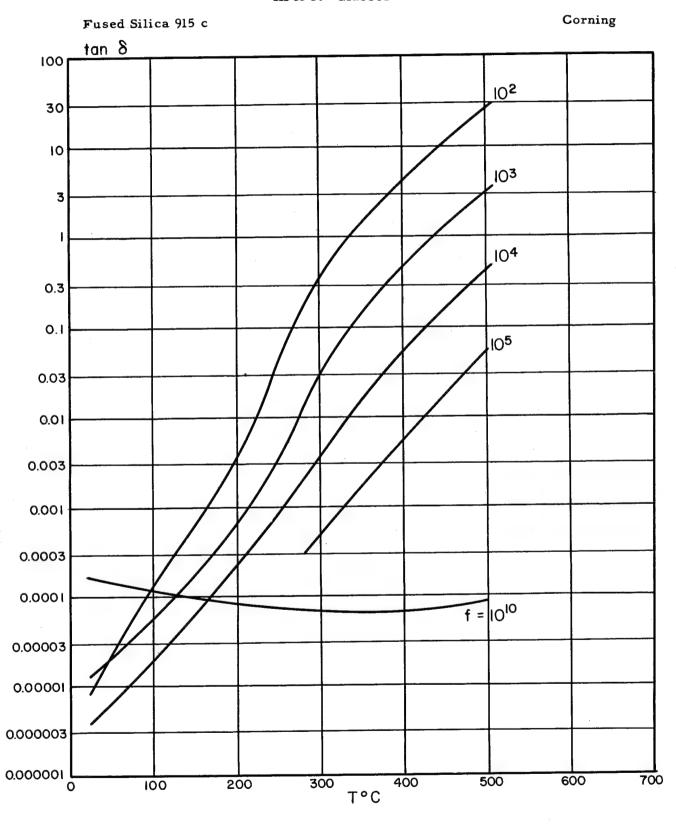




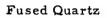
III A 3. Glasses



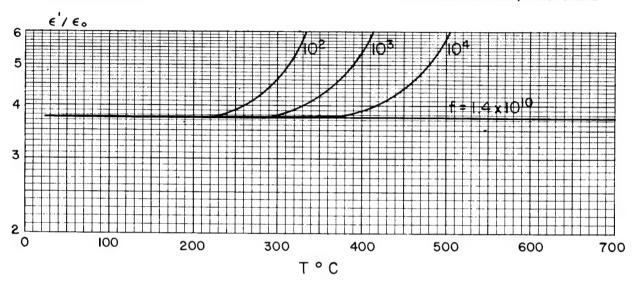
III A 3. Glasses



III A 3. Glasses

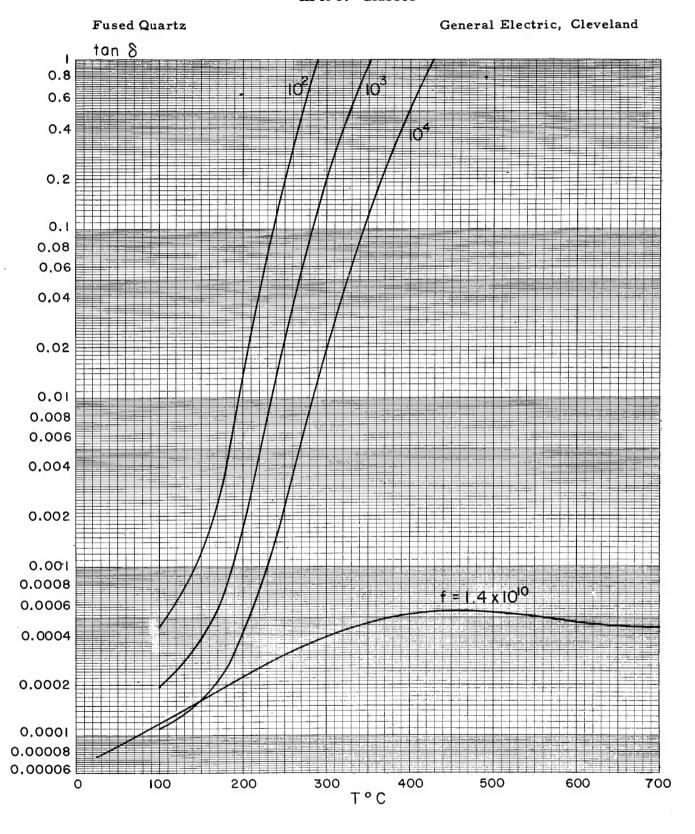


General Electric, Cleveland

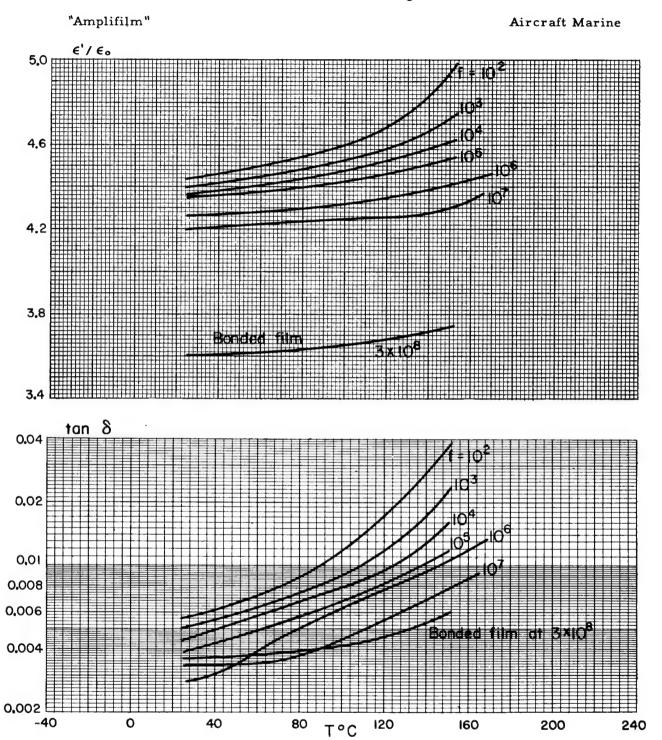


At 800° C, 1.4×10^{10} cycles, $\epsilon'/\epsilon_0 = 3.76$ and $\tan \delta = 0.00048$. At 1200° C, 5×10^{10} cycles, $\epsilon'/\epsilon_0 = 3.8 - 3.9$ and $\tan \delta < 0.002$.

III A 3. Glasses



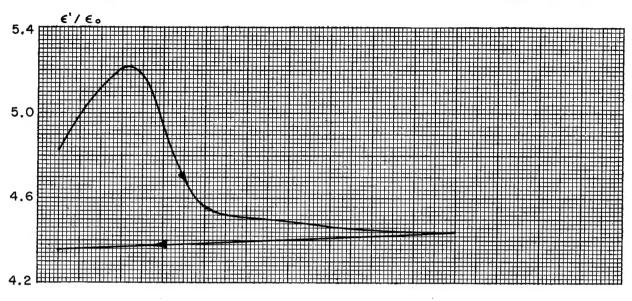
III A 4. Miscellaneous Inorganics

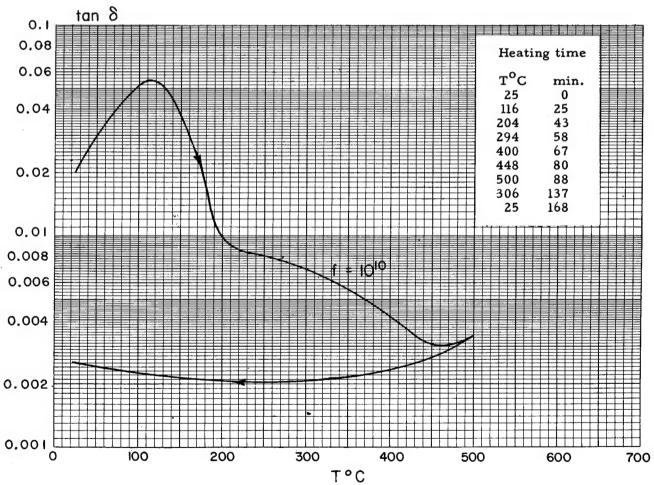


III A 4. Miscellaneous Inorganics



American Lava

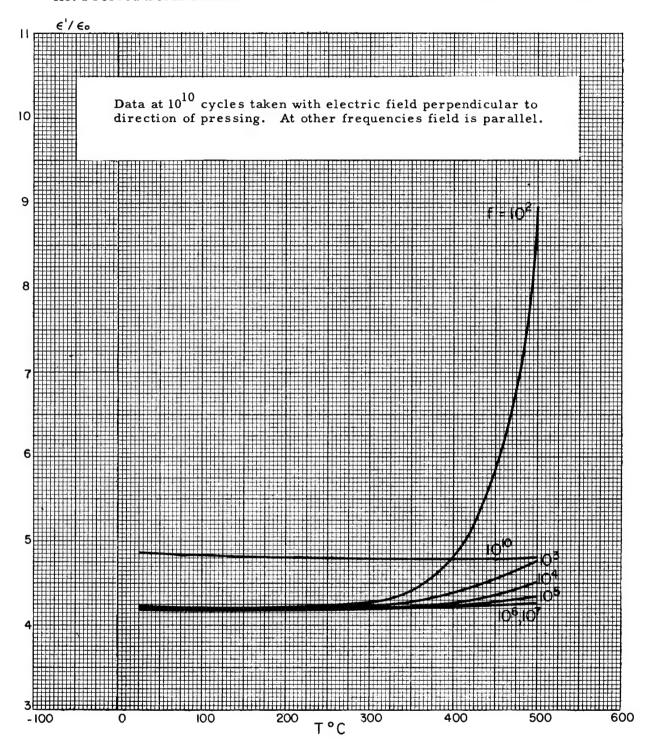




III A 4. Miscellaneous Inorganics

Hot Pressed Boron Nitride

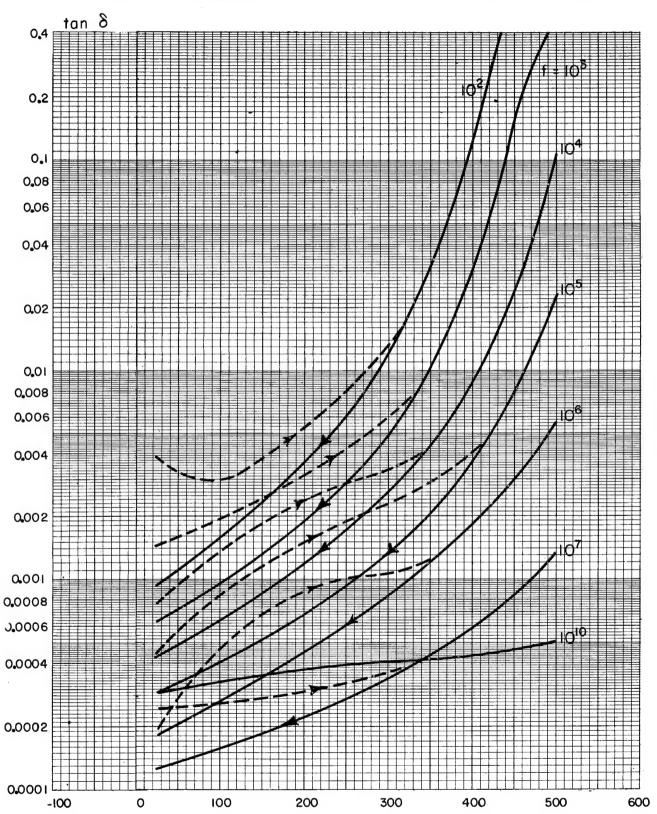
Carborundum Co.



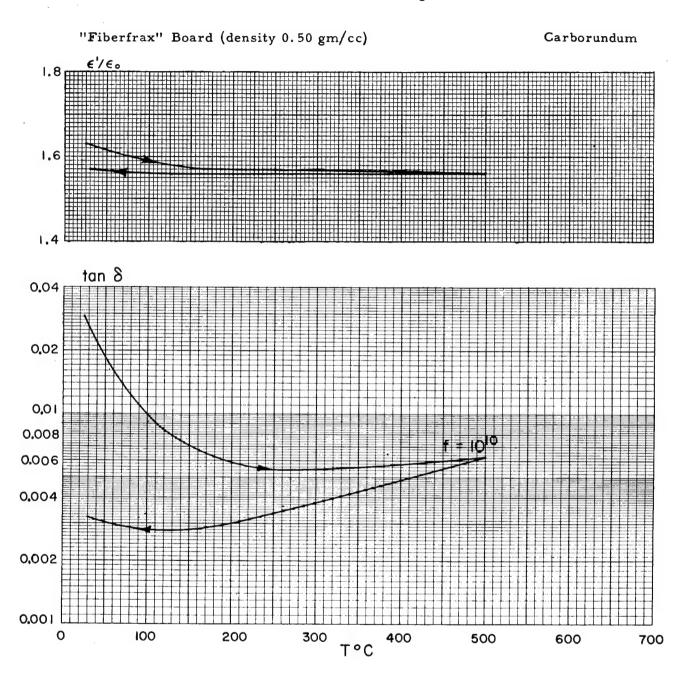
III A 4. Miscellaneous Inorganics

Hot Pressed Boron Nitride

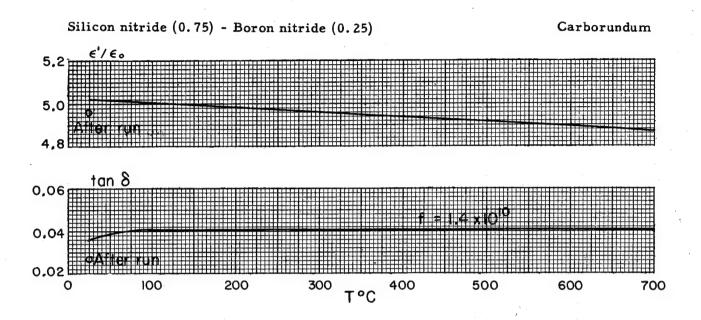
Carborundum Co.

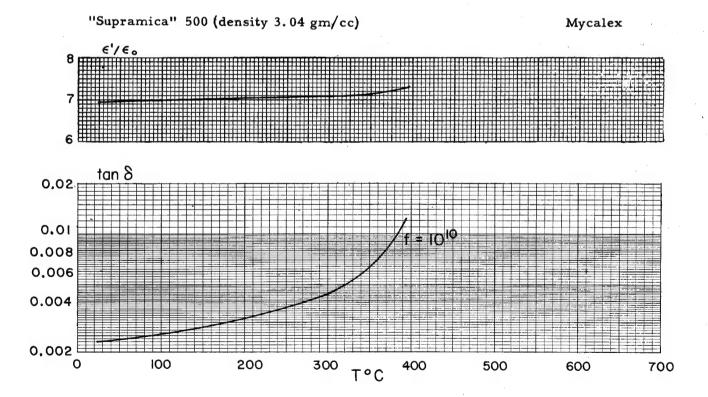


III A 4. Miscellaneous Inorganics

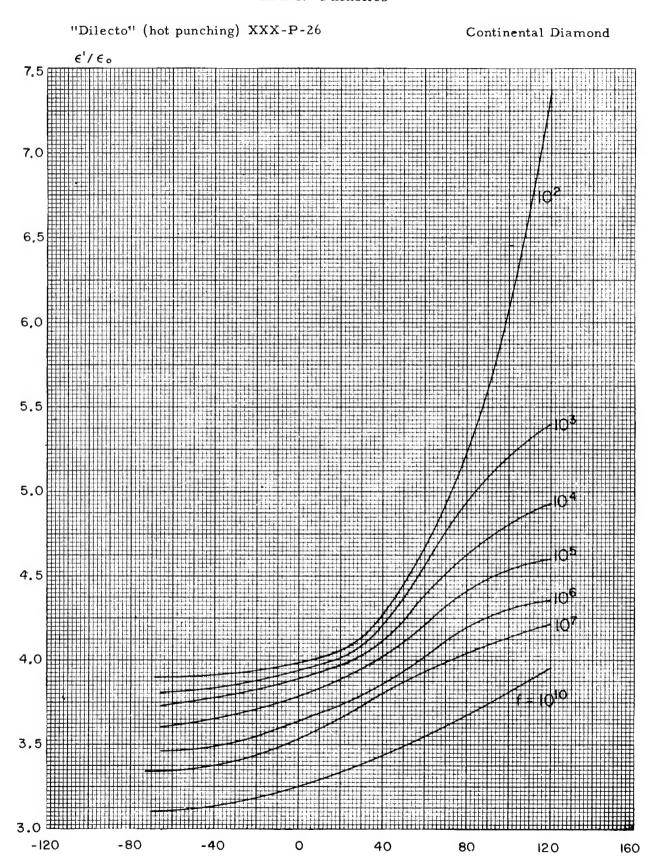


III A 4. Miscellaneous Inorganics

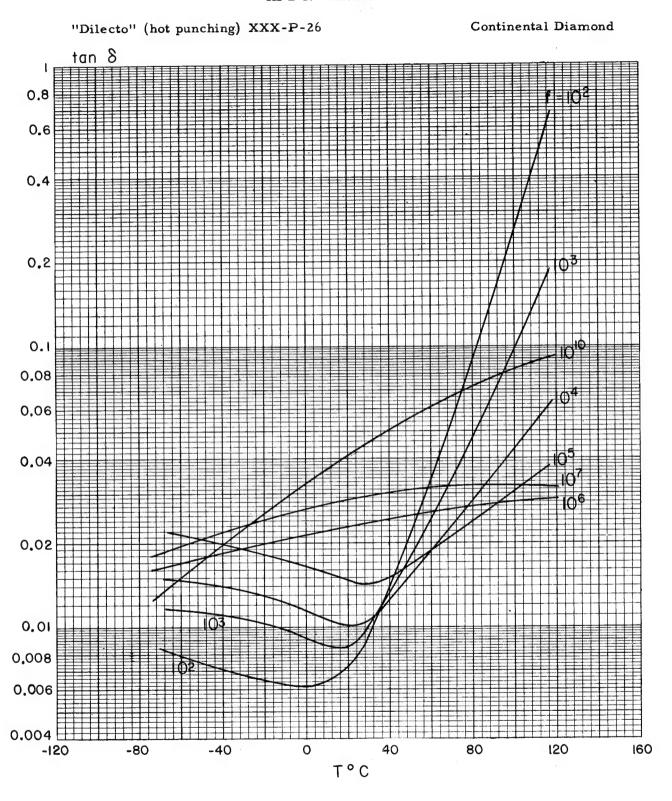




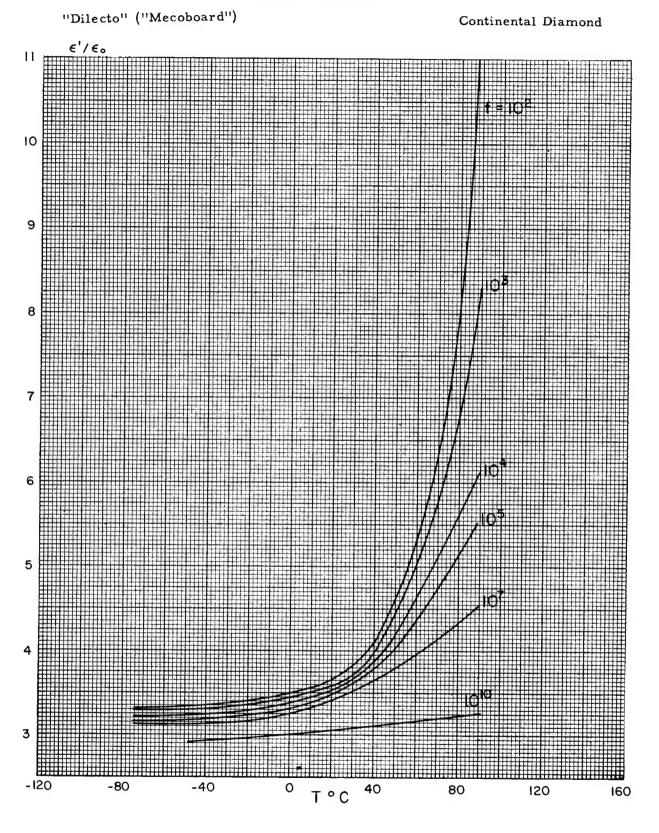
III B 1. Phenolics



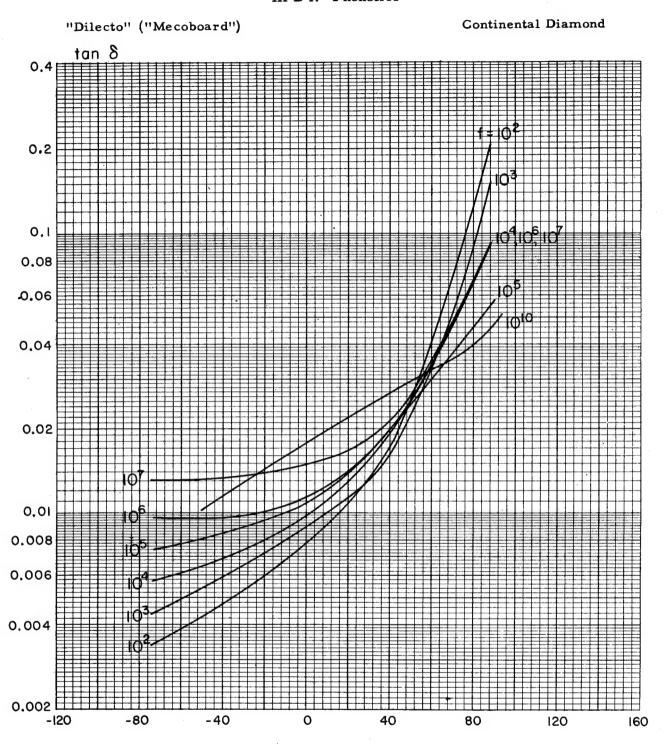
III B 1. Phenolics



III B 1. Phenolics



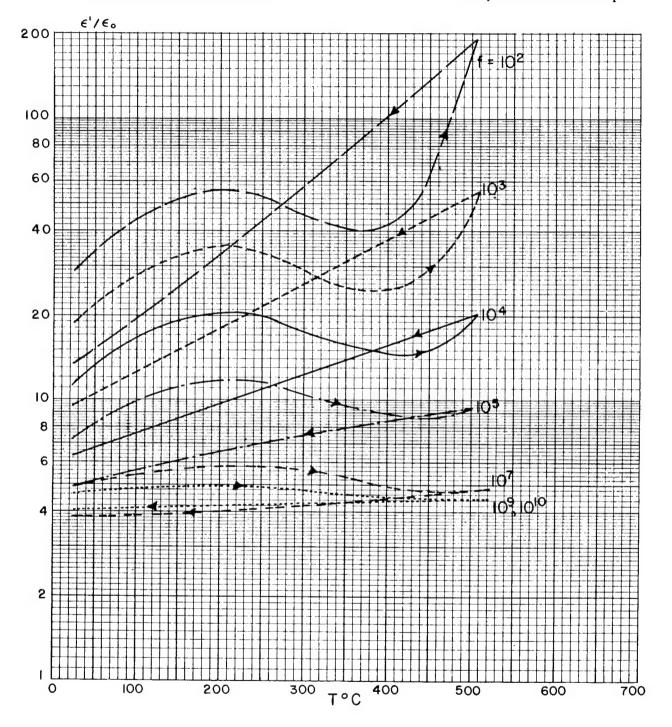
III B 1. Phenolics



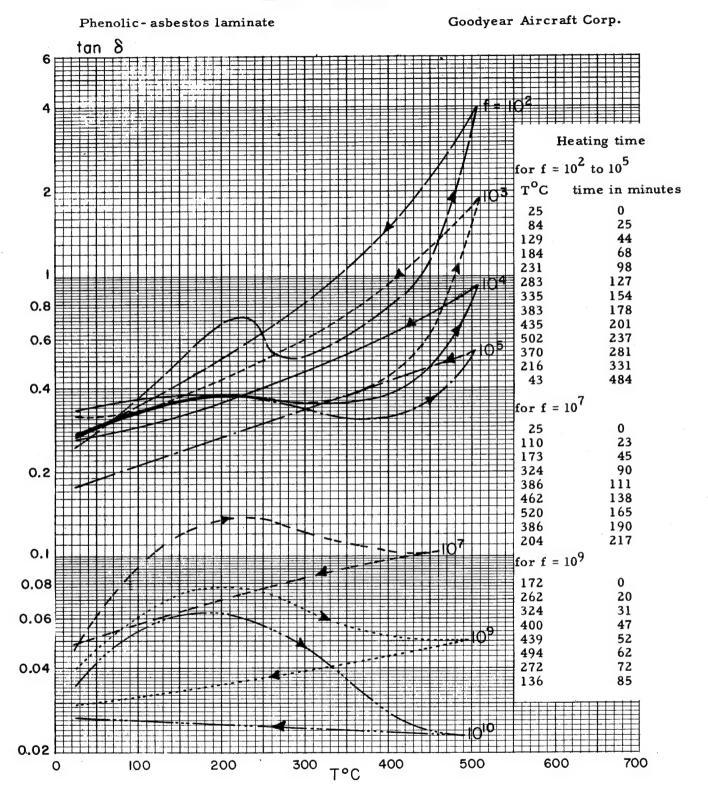
III B 1. Phenolics

Phenolic - asbestos laminate

Goodyear Aircraft Corp.



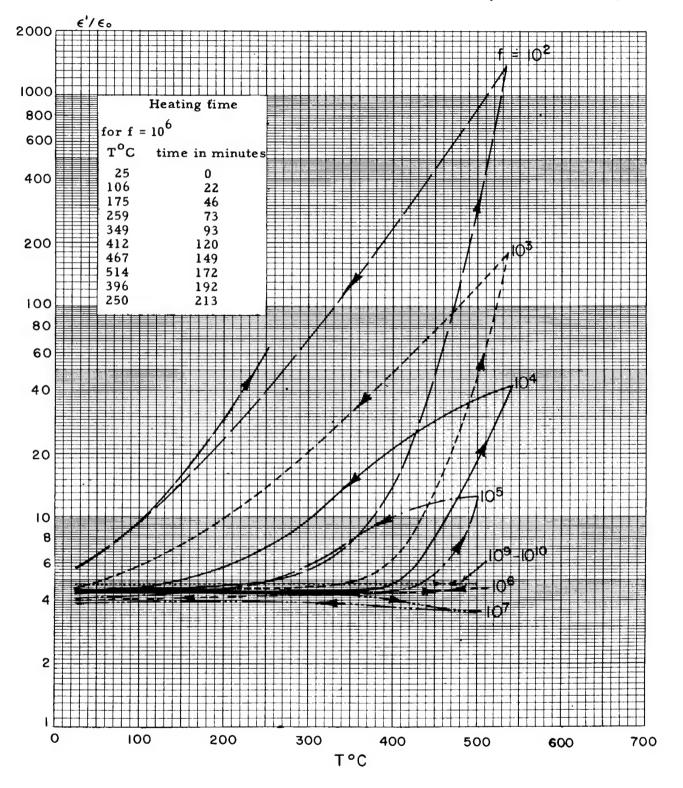
III B 1. Phenolics



III B 1. Phenolics

Phenolic-"fiberglas" laminate, pressed

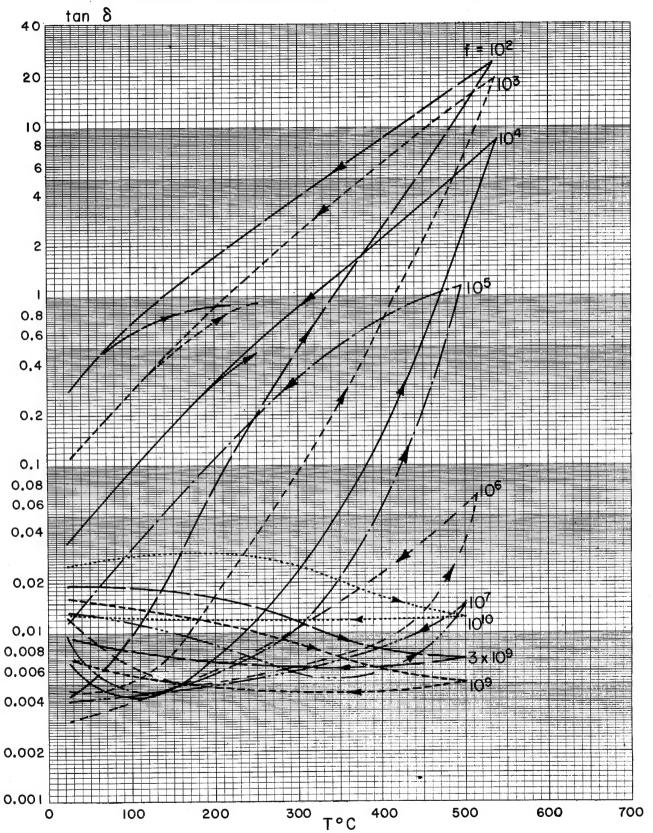
Goodyear Aircraft Corp.



III B 1. Phenolics

Phenolic-"fiberglas" laminate, pressed

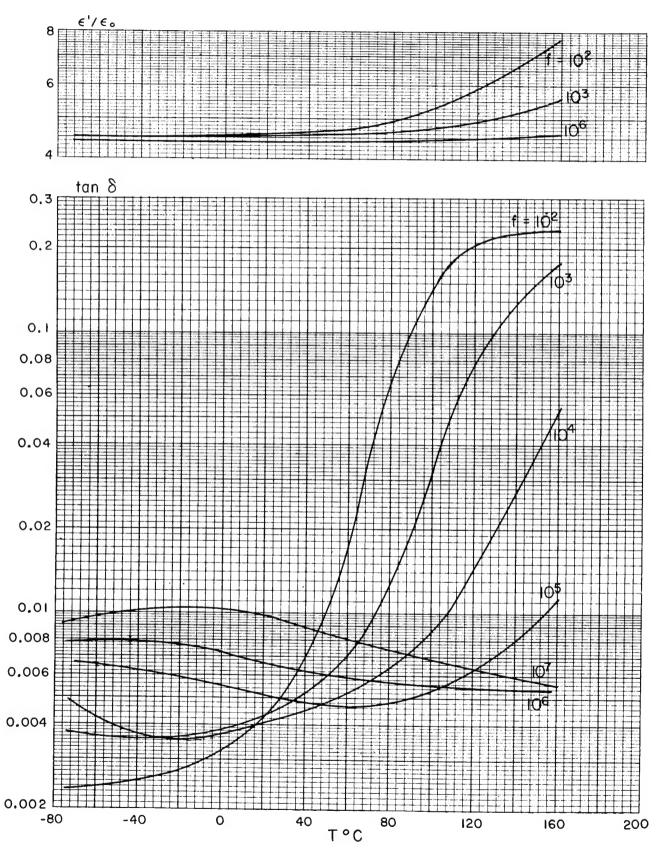
Goodyear Aircraft Corp.



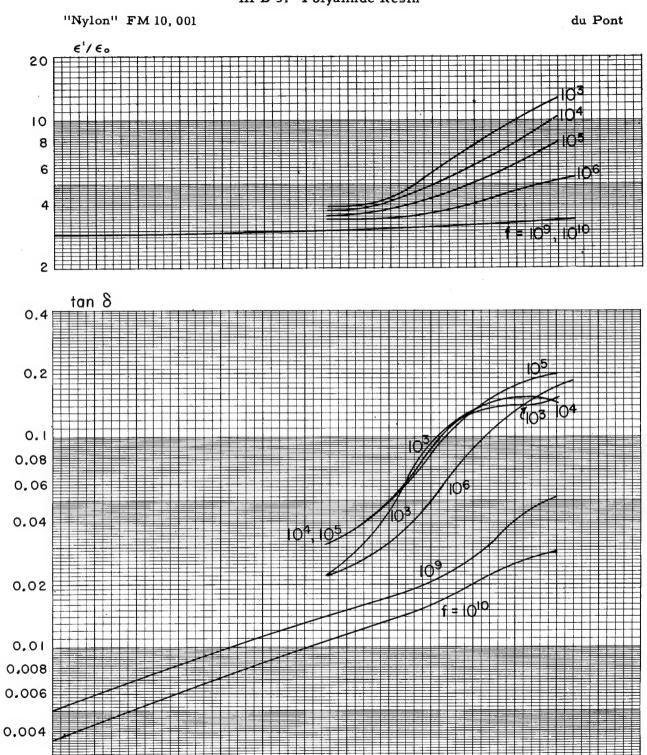
III B 2. Melamine Formaldehyde

"Dilecto" GM-1

Continental Diamond



III B 3. Polyamide Resin



T°C

60

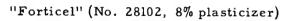
100

80

0.002 E -40

-20

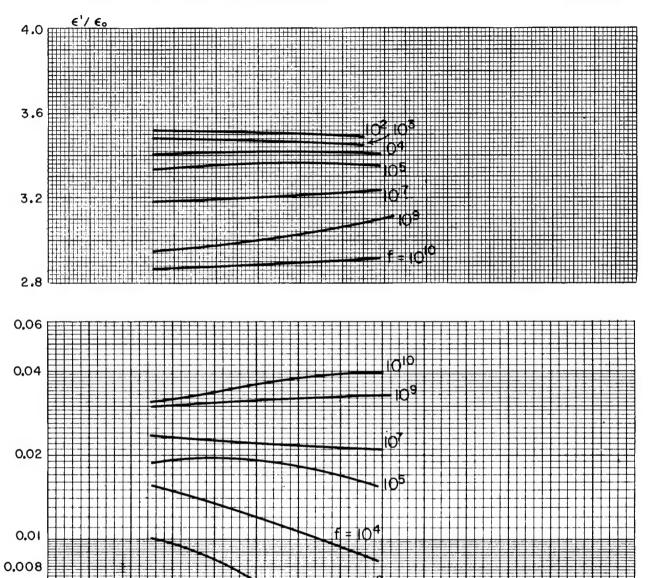
III B 4. Cellulose Derivatives



0.006

0.004 E

Celanese



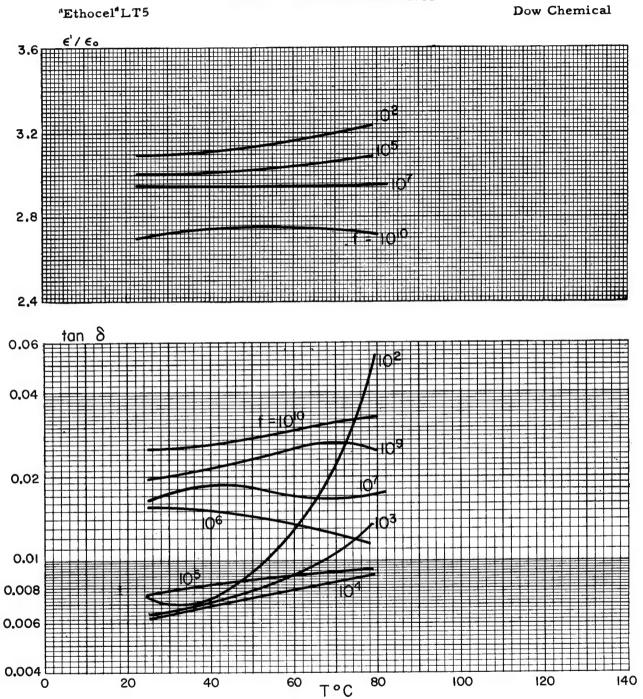
80

T°C

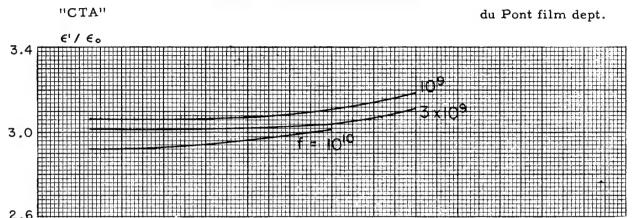
100

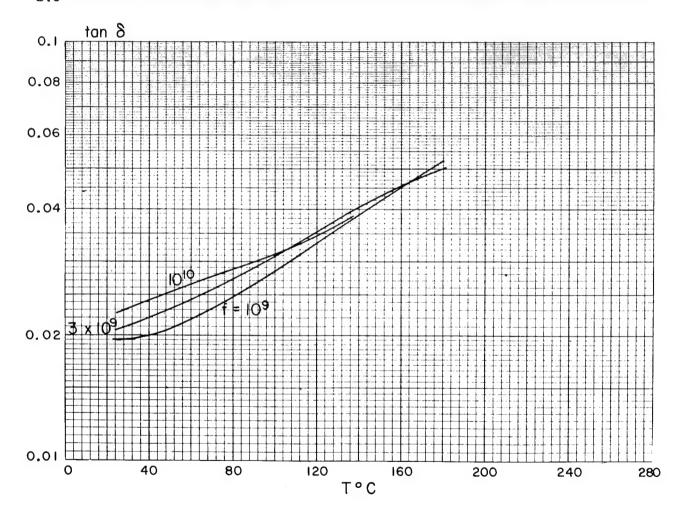
120

III B 4. Cellulose Derivatives

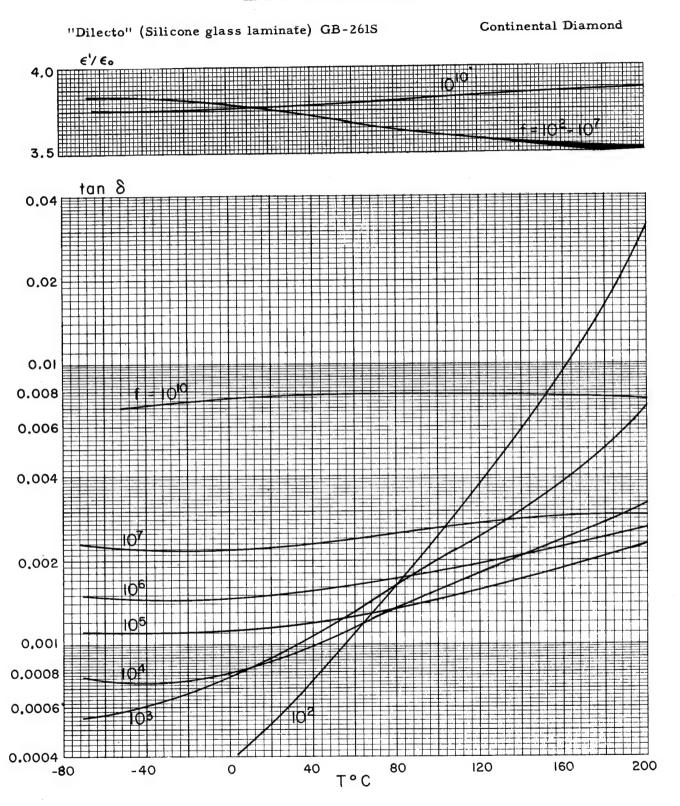


III B 4. Cellulose Derivatives

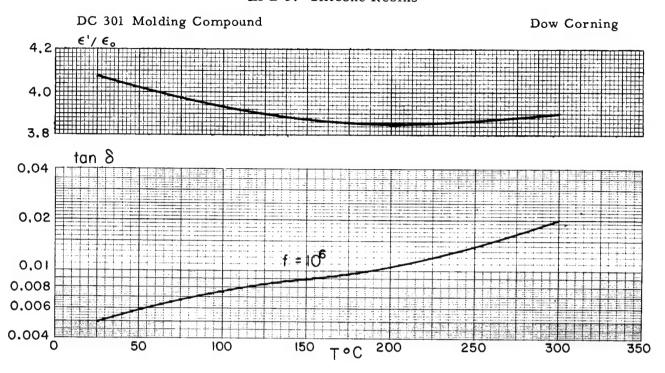


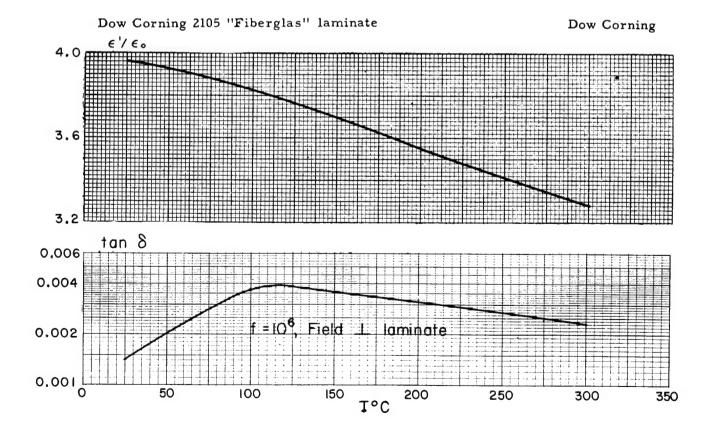


III B 5. Silicone Resins

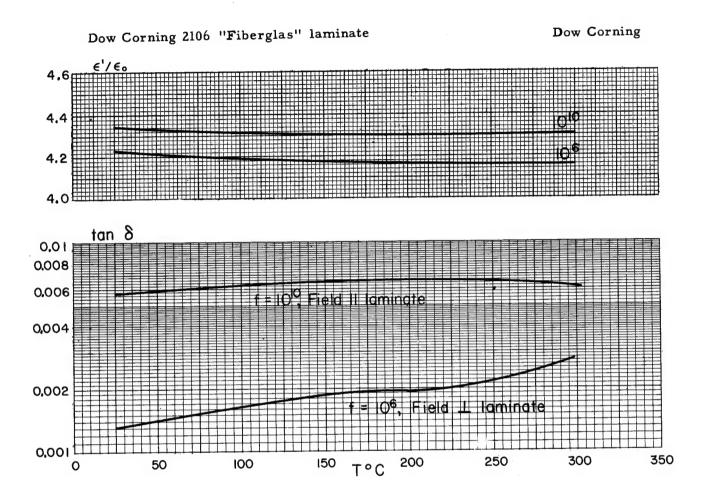


III B 5. Silicone Resins



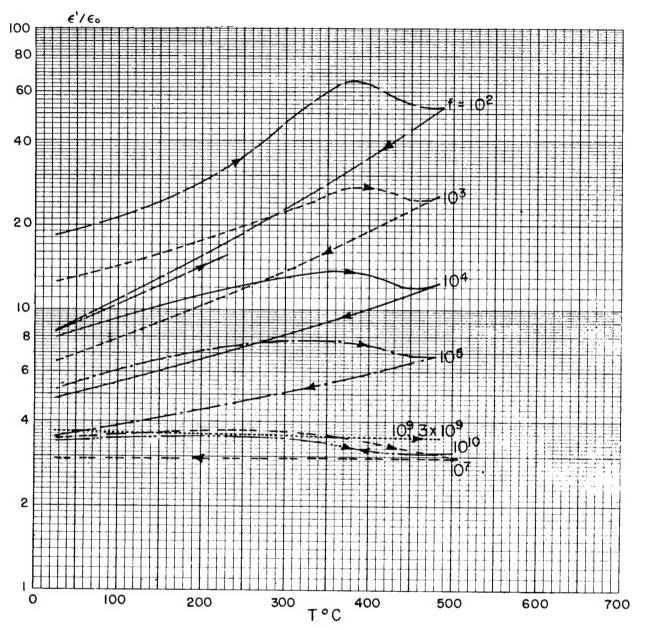


III B 5. Silicone Resins



III B 5. Silicone Resins

Silicone-asbestos laminate



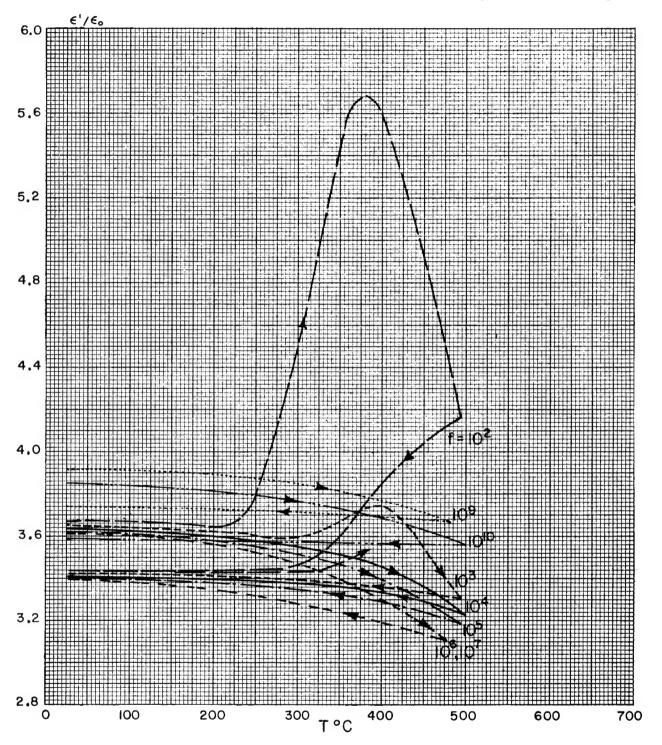
III B 5. Silicone Resins

Goodyear Aircraft Corp. Silicone-asbestos laminate tan 8 Heating time for $f = 10^7$ т°С time in minutes 25 47 70 87 113 167 506 0.8 188 388 205 0.6 0.4 0.08 0.06 0.04 0.02 0.01 400 500 600 700 100 200 300

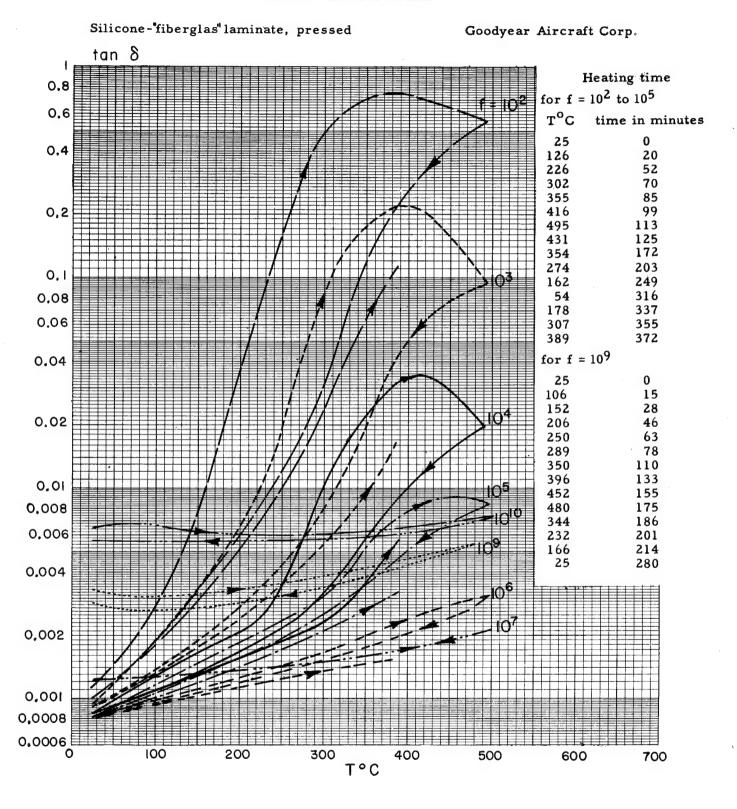
T°C

III B 5. Silicone Resins

Silicone-"fiberglas" laminate, pressed

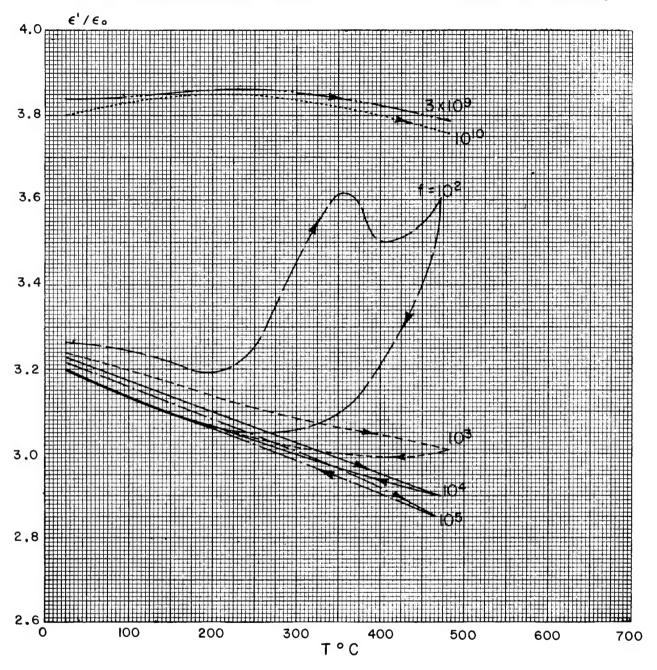


III B 5. Silicone Resins

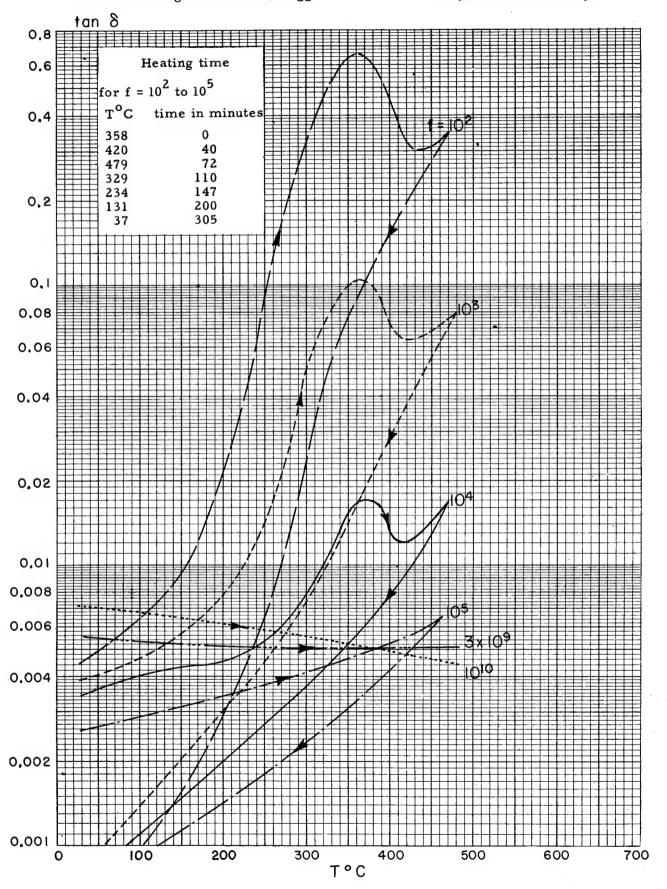


III B 5. Silicone Resins

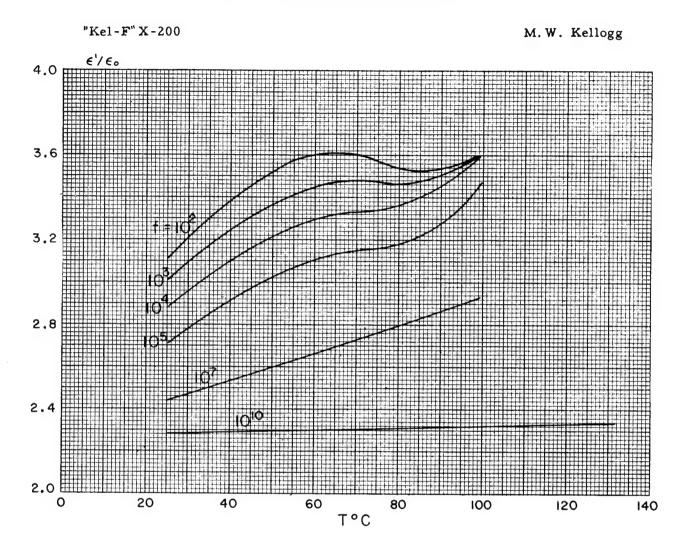
Silicone-"fiberglas" laminate, bagged



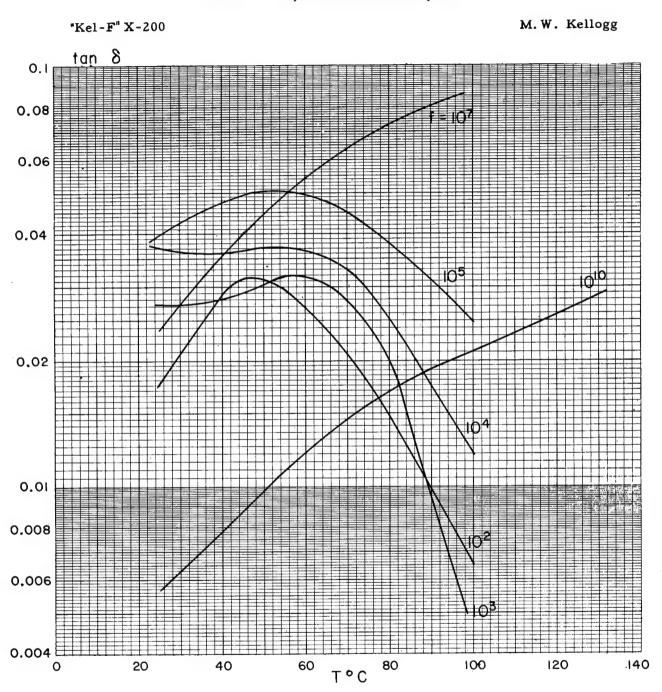
Silicone-"fiberglas" laminate, bagged



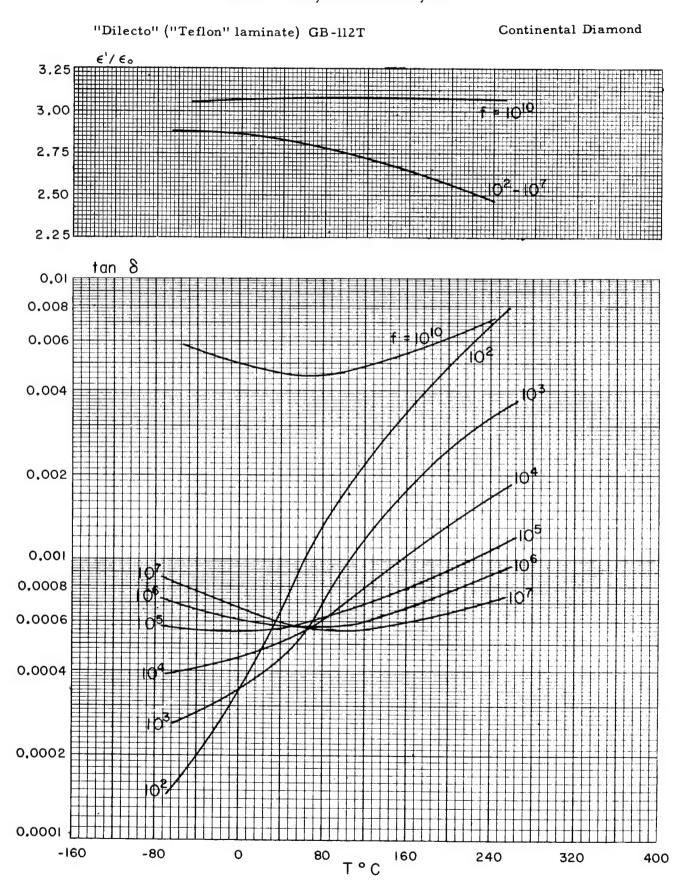
III B 6. Polychlorotrifluoroethylene



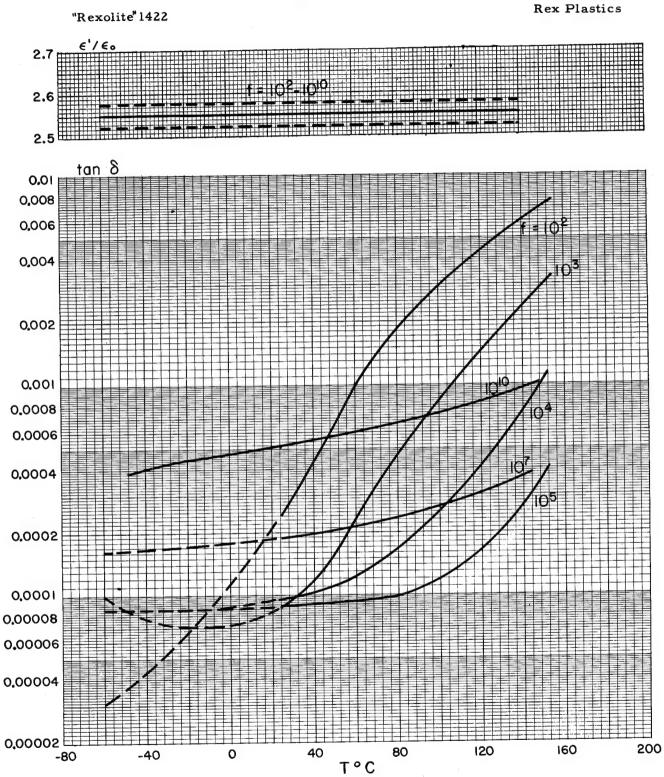
III B 6. Polychlorotrifluoroethylene



III B 7. Polytetrafluoroethylene



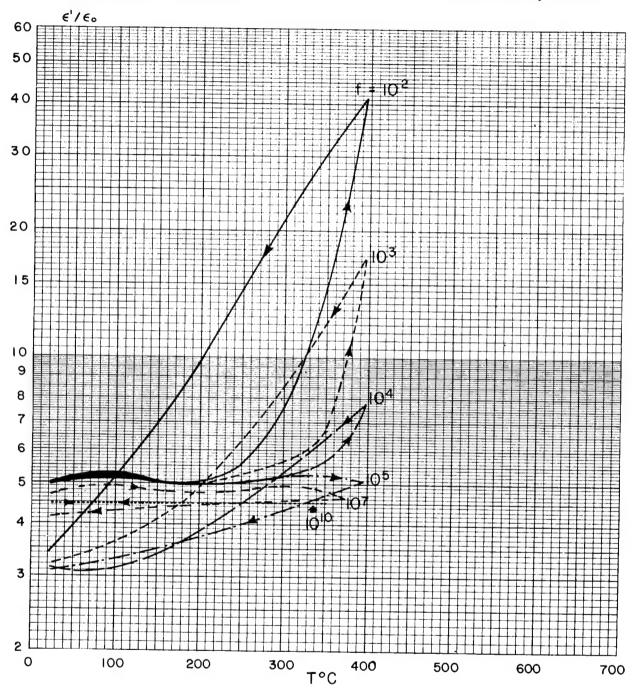
III B 8. Styrene Copolymers



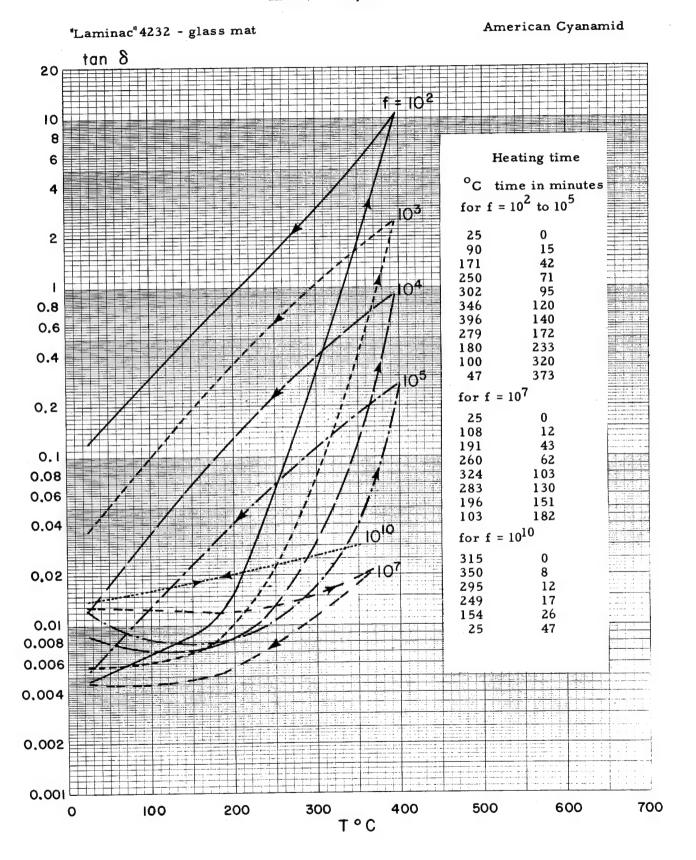
III B 9. Polyesters

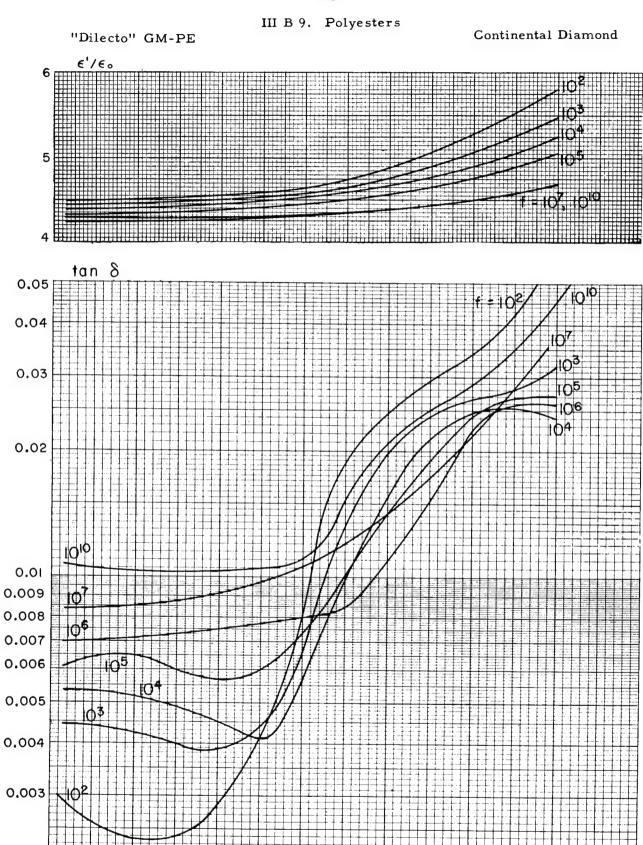


American Cyanamid



III B 9. Polyesters





40

T°C

80

120

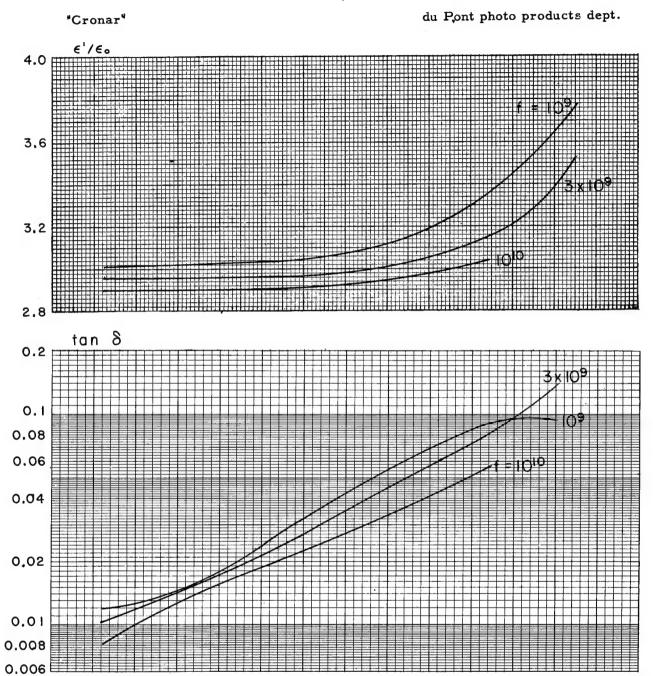
160

200

0.002

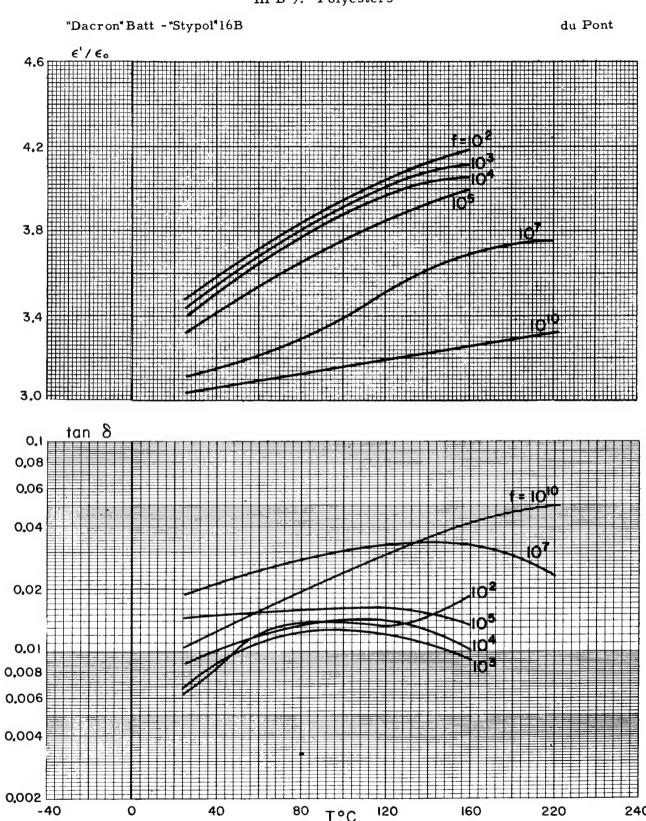
-40

III B 9. Polyesters



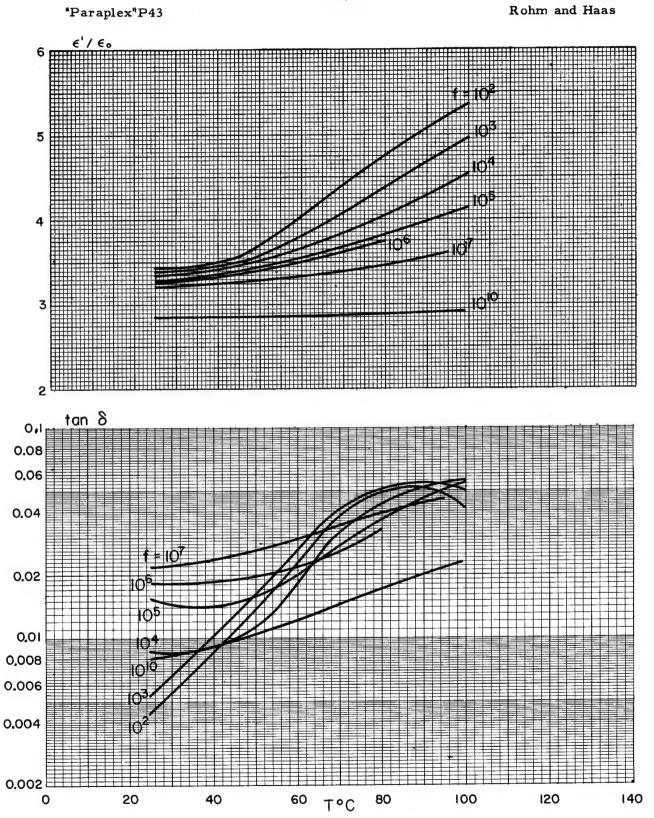
T°C

III B 9. Polyesters

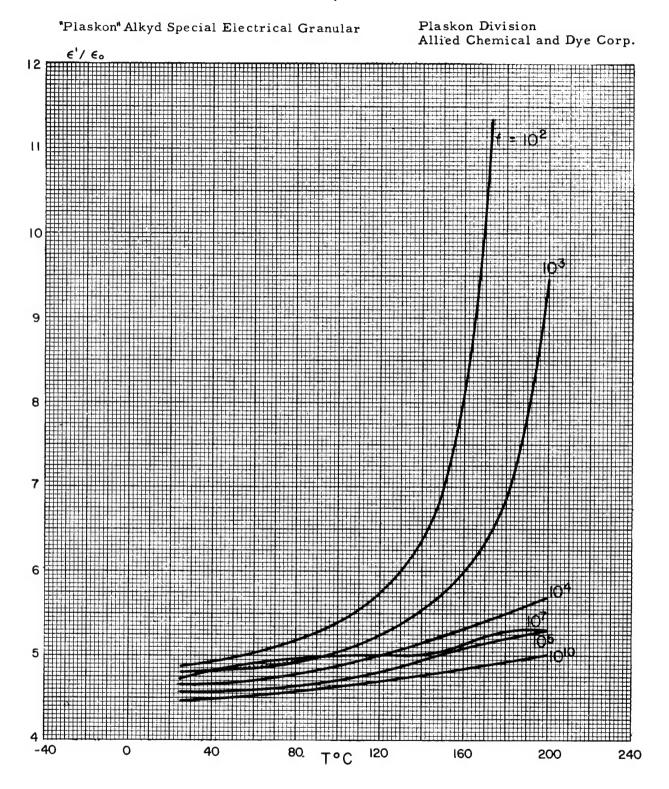


T°C

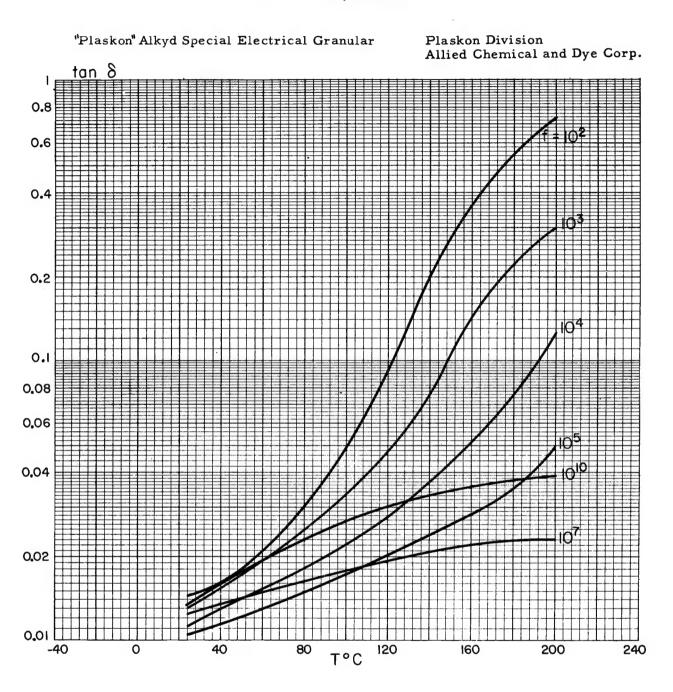
III B 9. Polyesters



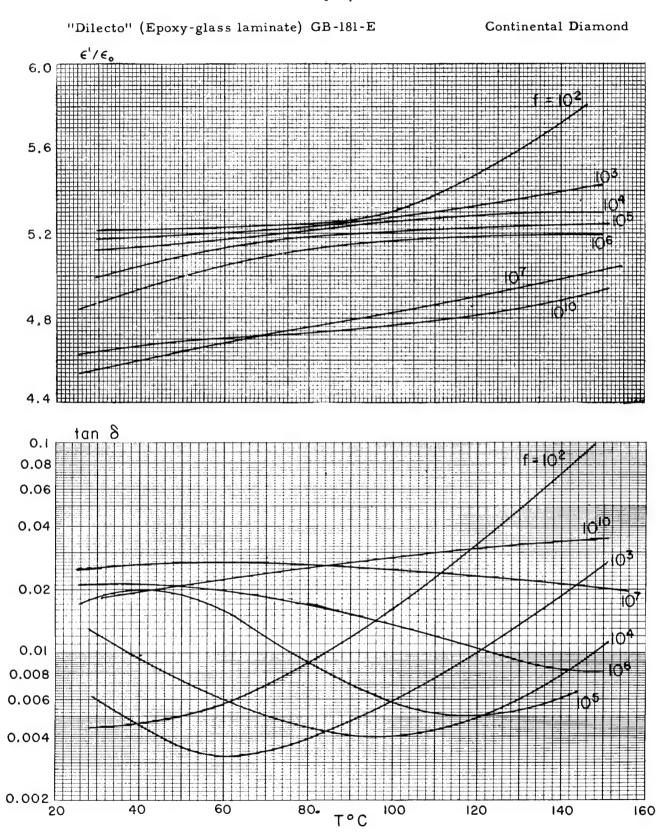
III B 10. Alkyd Resins



III B 10. Alkyd Resins



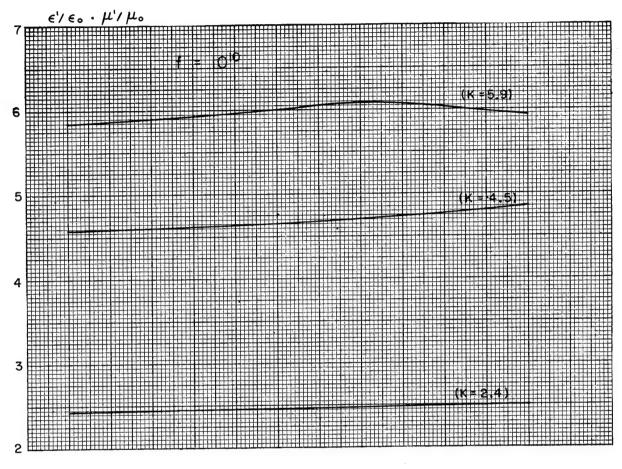
III B 11. Epoxy Resins

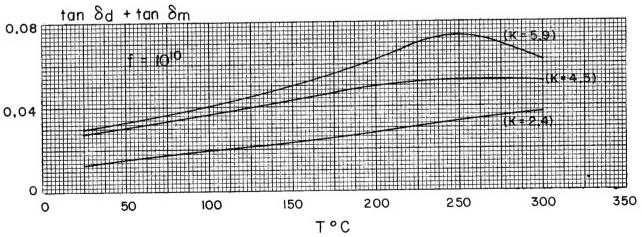


III B 11. Epoxy Resins

"Eccofoam" HiK (500°F) (K=5.9, K=4.5, K=2.4)

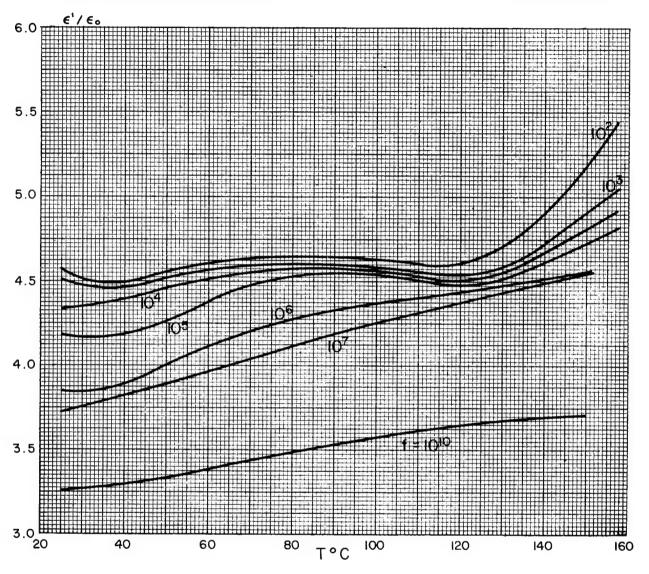
Emerson and Cuming



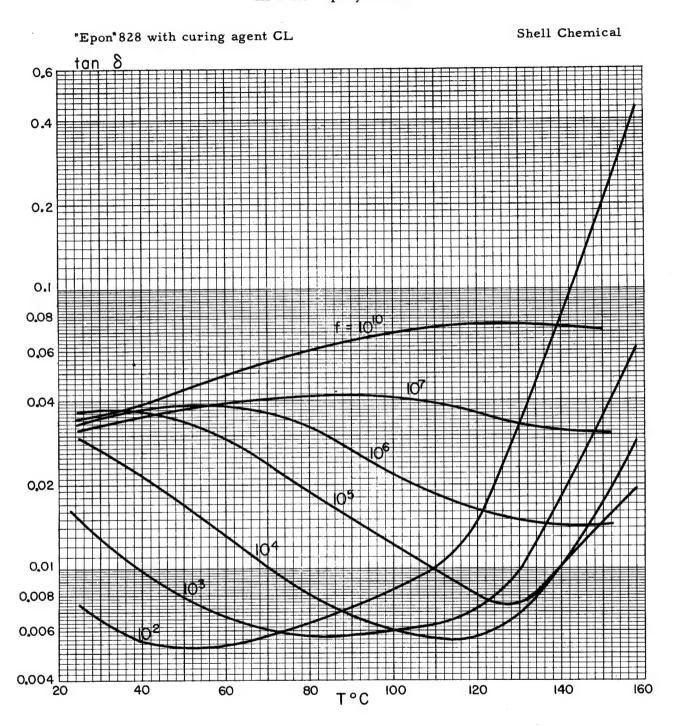


III B 11. Epoxy Resins

"Epon" 828 with curing agent CL

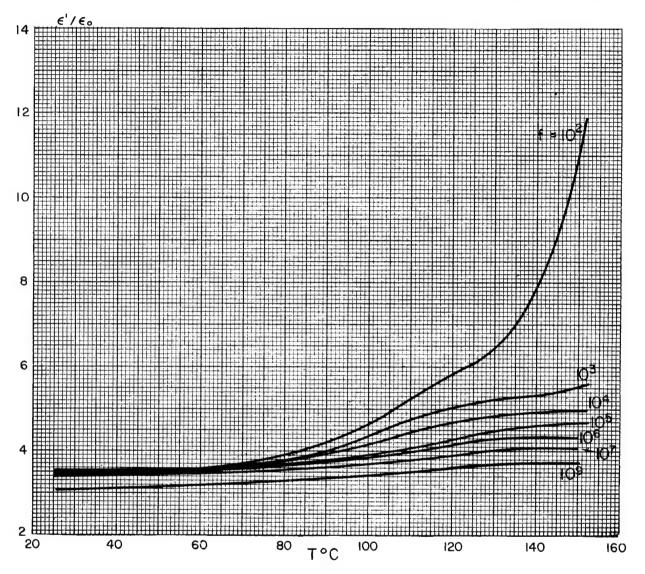


III B 11. Epoxy Resins

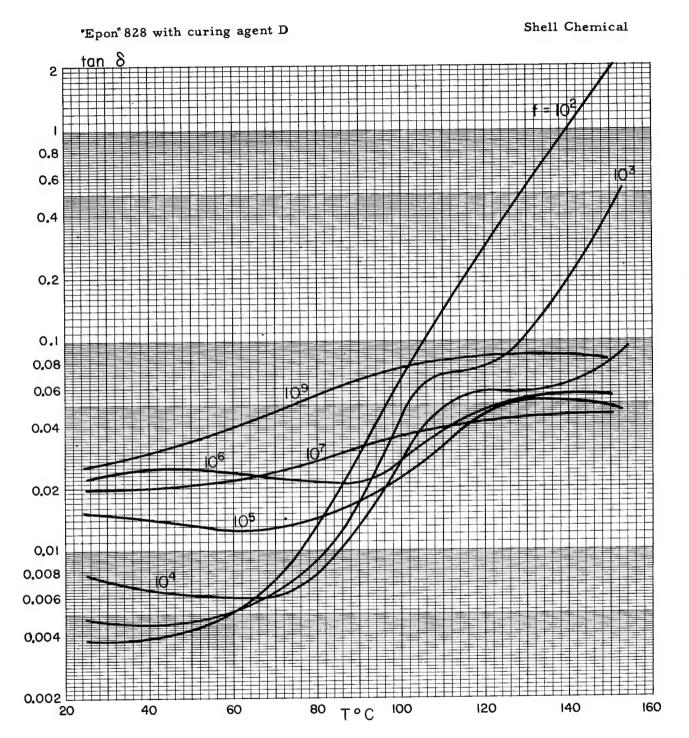


III B 11. Epoxy Resins

"Epon" 828 with curing agent D

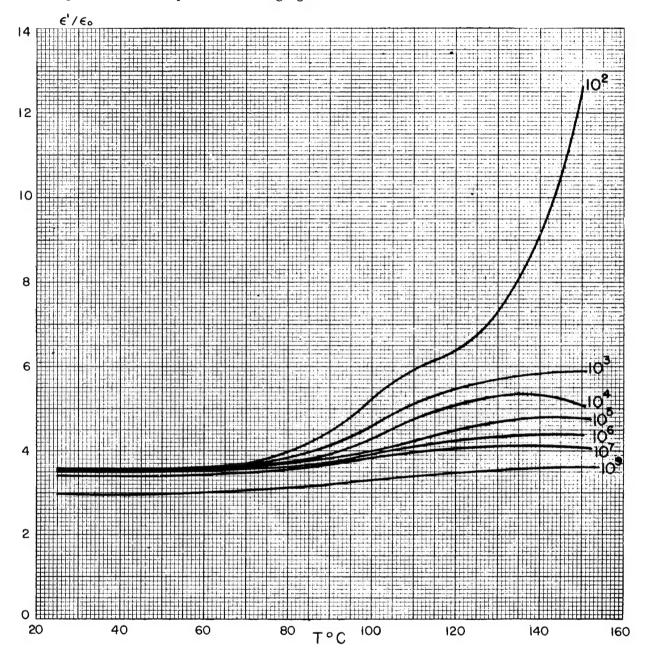


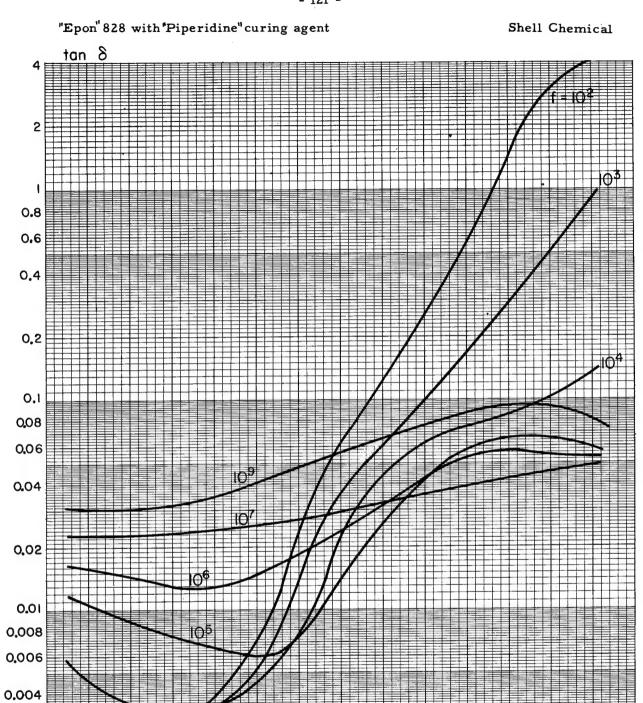
III B 11. Epoxy Resins



III B 11. Epoxy Resins

"Epon" 828 with "Piperidine" curing agent



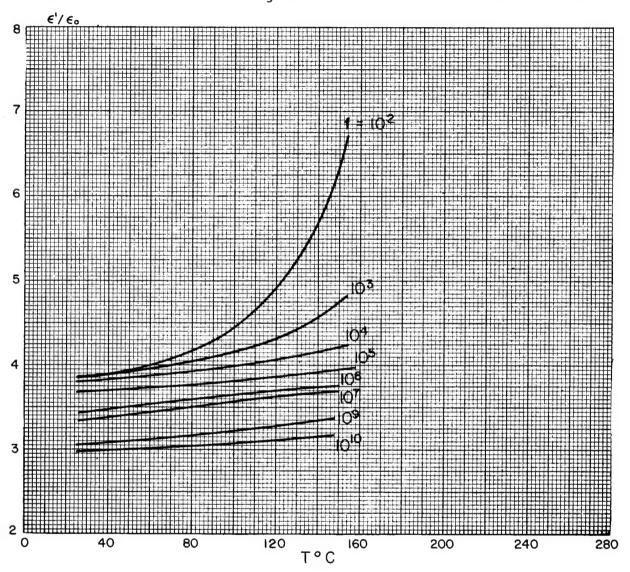


0.002

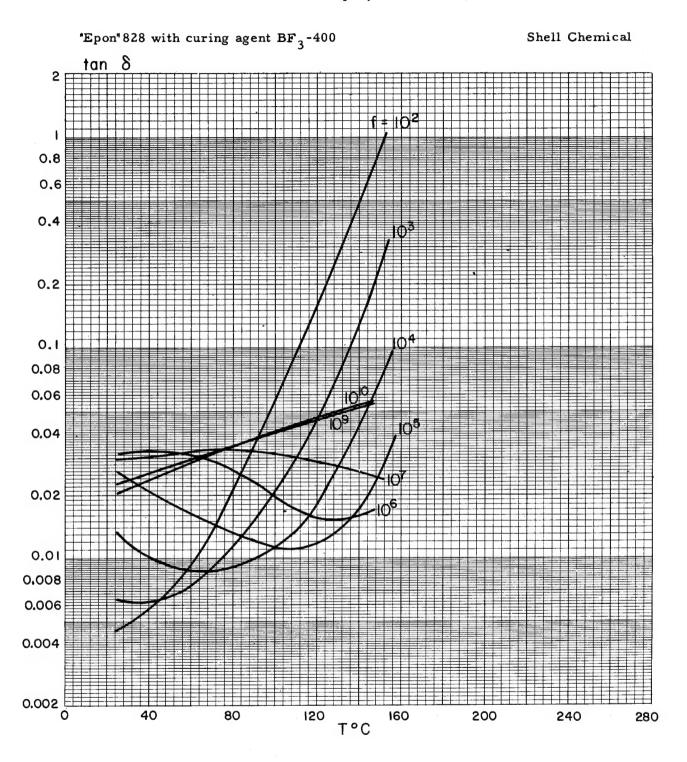
0,001

III B 11. Epoxy Resins

"Epon" 828 with curing agent BF $_3$ -400

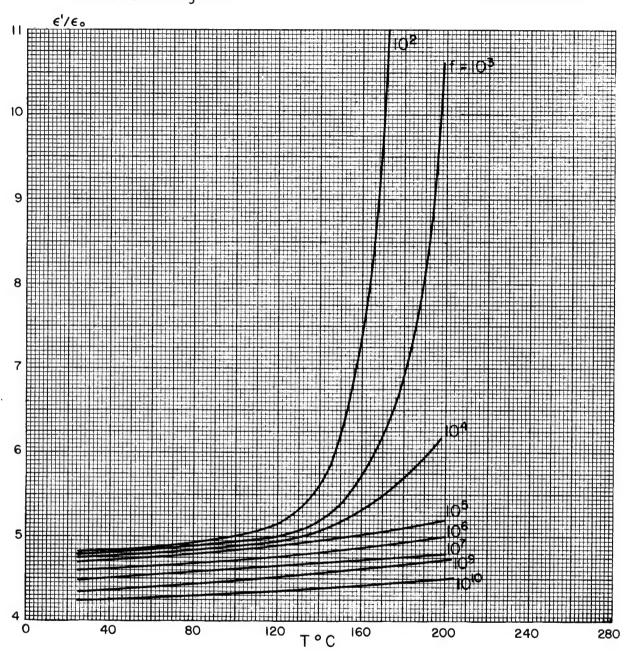


III B 11. Epoxy Resins

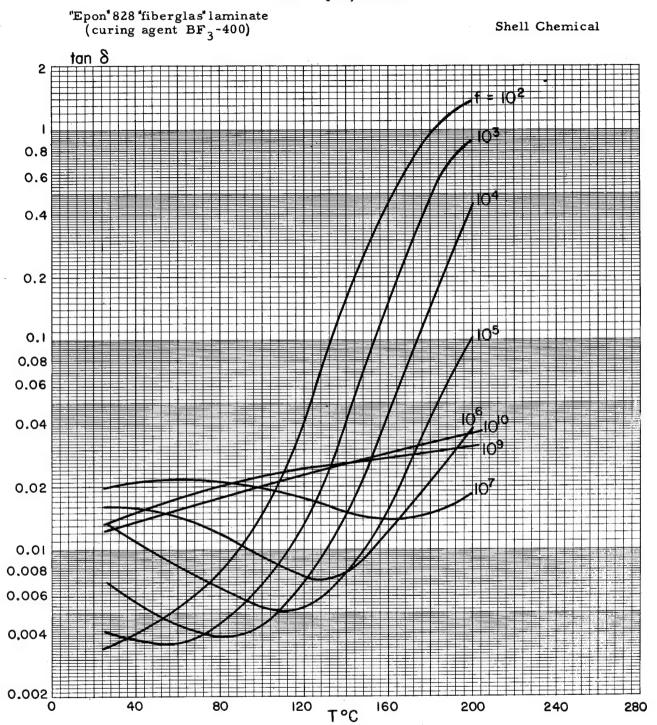


III B 11. Epoxy Resins

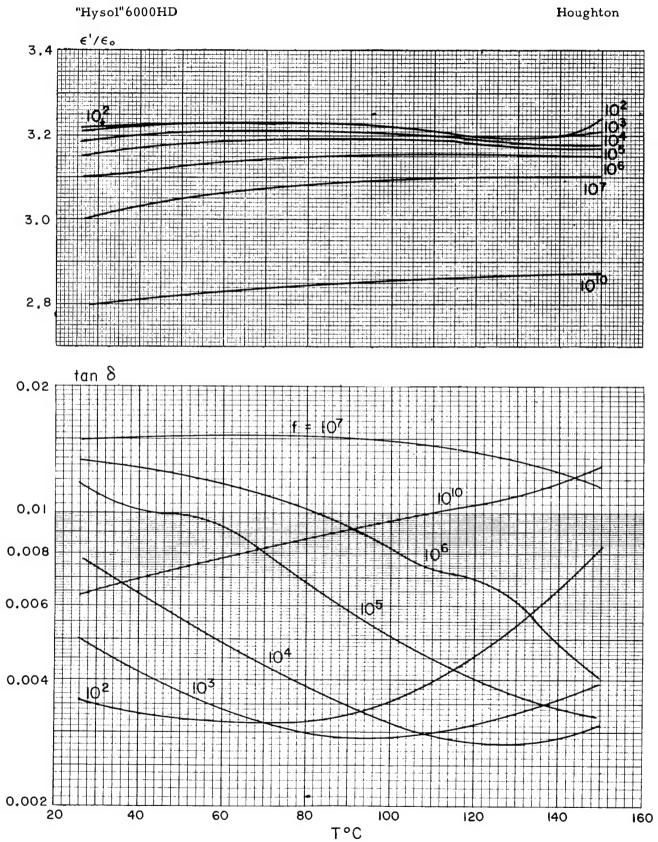
"Epon" 828 fiberglas laminate (curing agent BF 3-400)



III B 11. Epoxy Resins



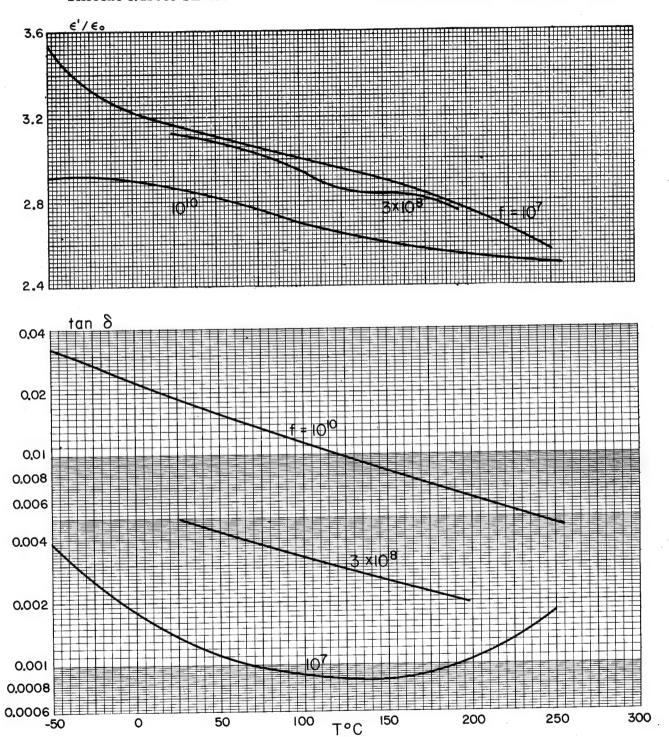
III B 11. Epoxy Resins



III C. Elastomers

Silicone Rubber SE 450

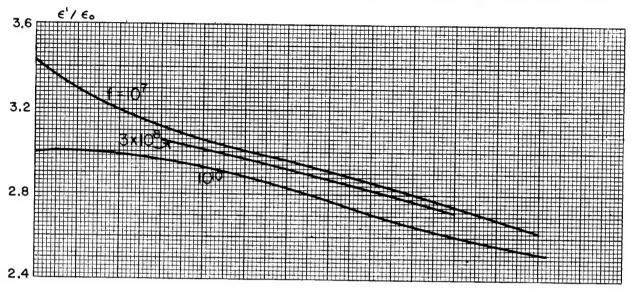
General Electric, Waterford, N.Y.

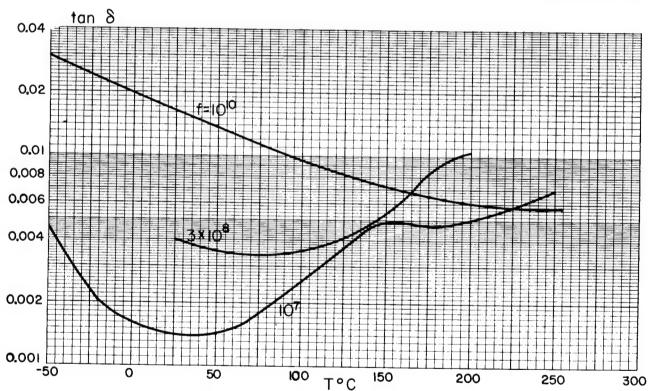


III C. Elastomers

Silicone Rubber SE 460

General Electric, Waterford, N.Y.

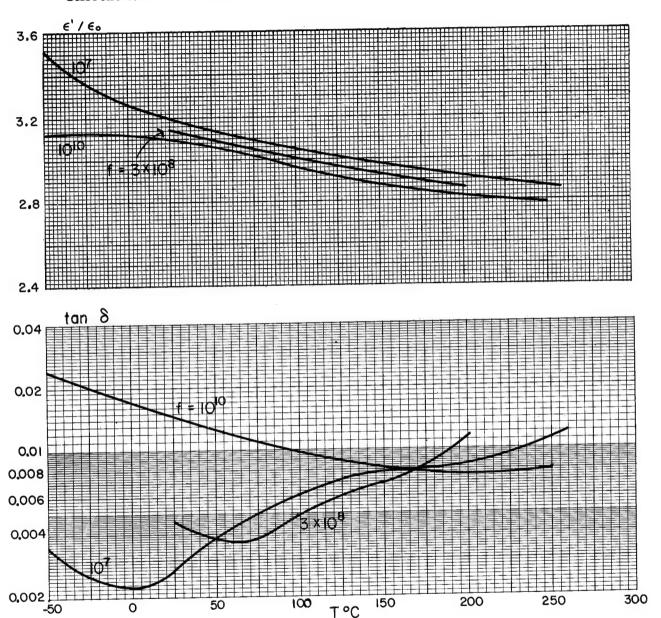




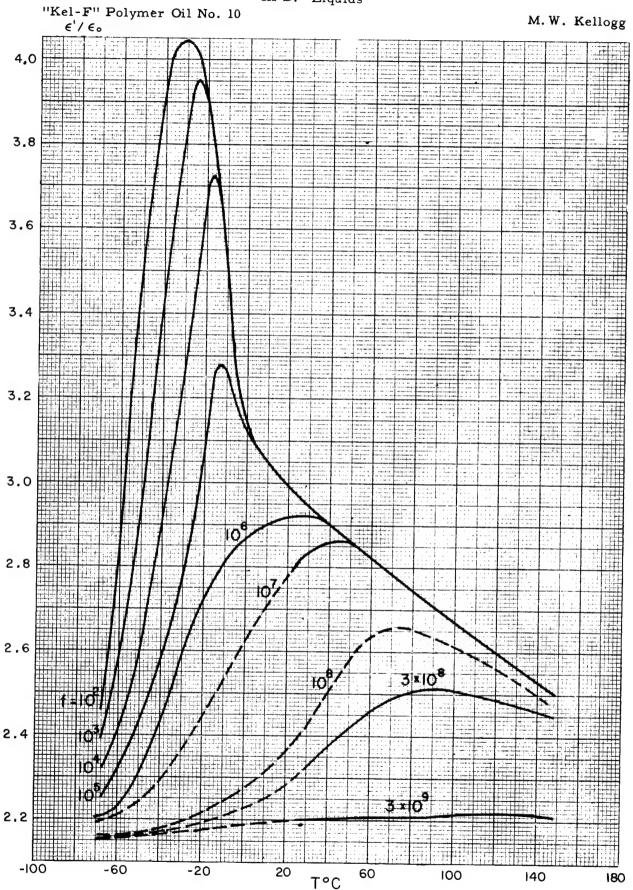
III C. Elastomers

Silicone Rubber SE 972

General Electric, Waterford, N.Y.



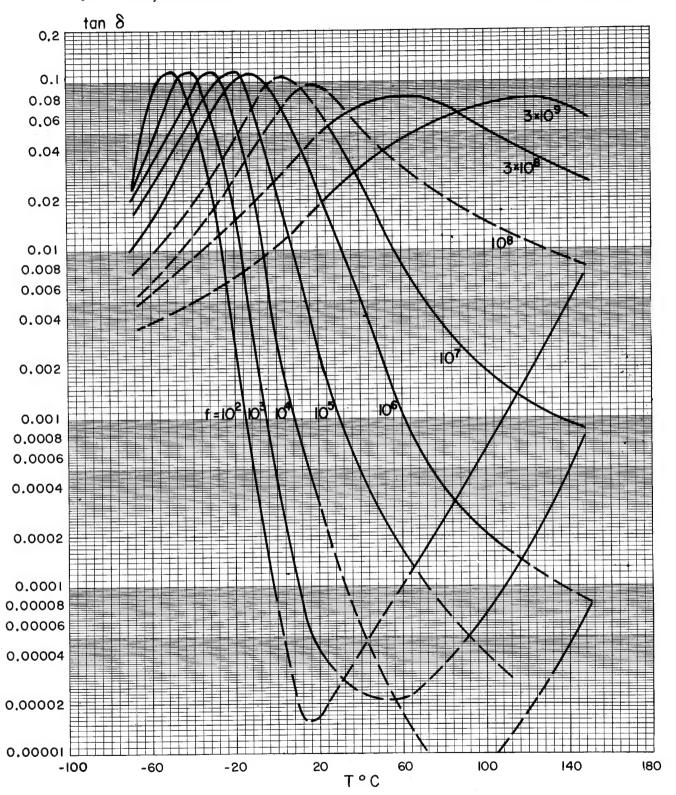
III D. Liquids



III D. Liquids

"Kel-F" Polymer Oil No. 10

M.W. Kellogg



IV. Ferromagnetic Dielectrics

Complete evaluation of a magnetic material for both scientific study and engineering design requires measurement of ** and ** vs. frequency, temperature, a-c field strength, and d-c bias. Phenomena of interest range from the very slow changes in magnetization with time at low temperatures to the instantaneous permeability at high microwave power.

In this section we have limited our data to κ^* and κ^*_m vs. frequency at low a-c field strengths and fixed temperatures and to the quasi-static hysteresis loops at room temperature. At frequencies up to 10 Mc we have also plotted $\kappa_m^{\prime\prime}/\kappa_m^\prime$, a figure of merit for core materials. In the literature this is designated as $1/\mu'Q$ and called loss factor.

For many of the laboratory materials and some of the commercial materials other measurements have been made such as:

D-c conductivity vs. temperature,

- $\kappa \text{**}\text{, }\kappa \text{*}\text{*}\text{m}$ vs. temperature at fixed frequencies, low fields,
- K*, K* vs. field strength at fixed frequencies and temperatures.

 Some of this information is included in Tech. Rep. 97, a revised version of which will be published in Revs. Mod. Phys., July, 1957, and in a forthcoming technical report by D.J. Epstein. Other data are available from the measurements group file.

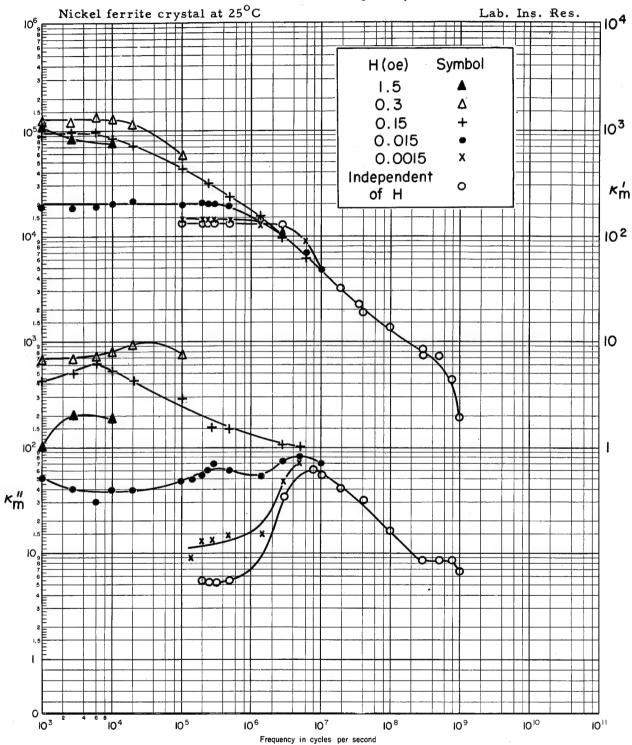
Details of the preparation of ferrites have been given in Tech. Rep. 78 by G. Economos.

Unless otherwise noted, measurements were taken at $26^{\circ}C \pm 1$. σ is given in mho/m.

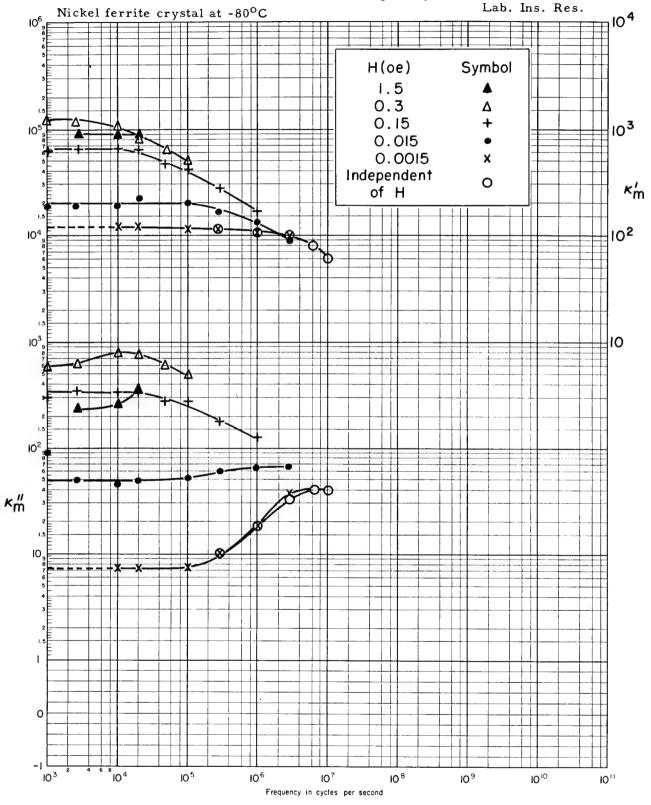
Low-frequency dielectric measurements marked were four-terminal measurements made to eliminate electrode effects.

IV A. Low Field-Strength Data at Fixed Temperatures as a Function of Frequency

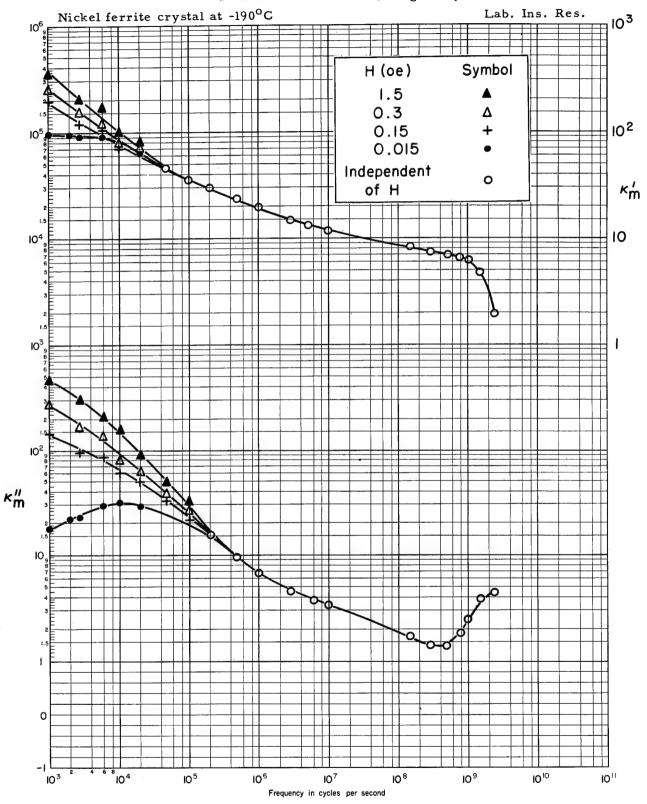
1. Nickel Ferrite, Single Crystal

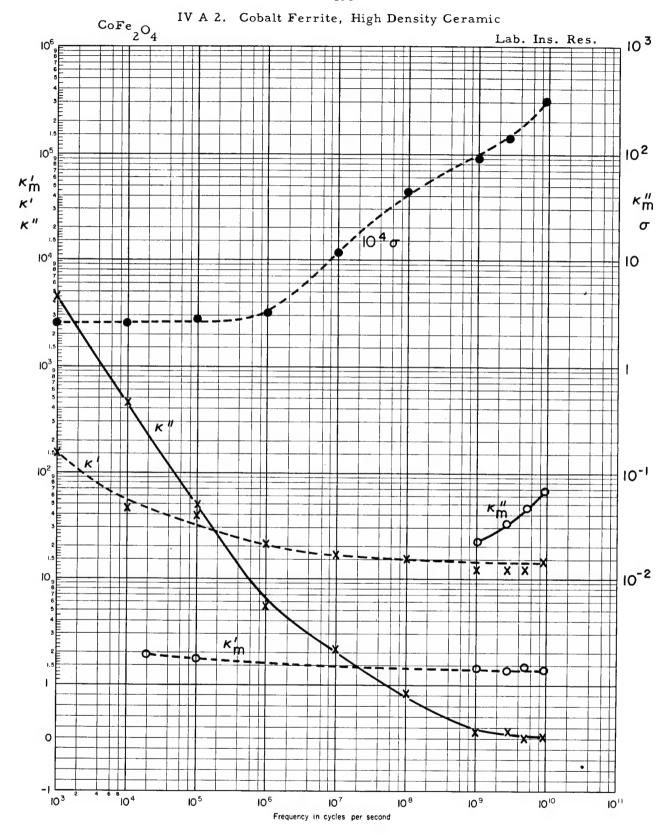


IV A 1. Nickel Ferrite, Single Crystal

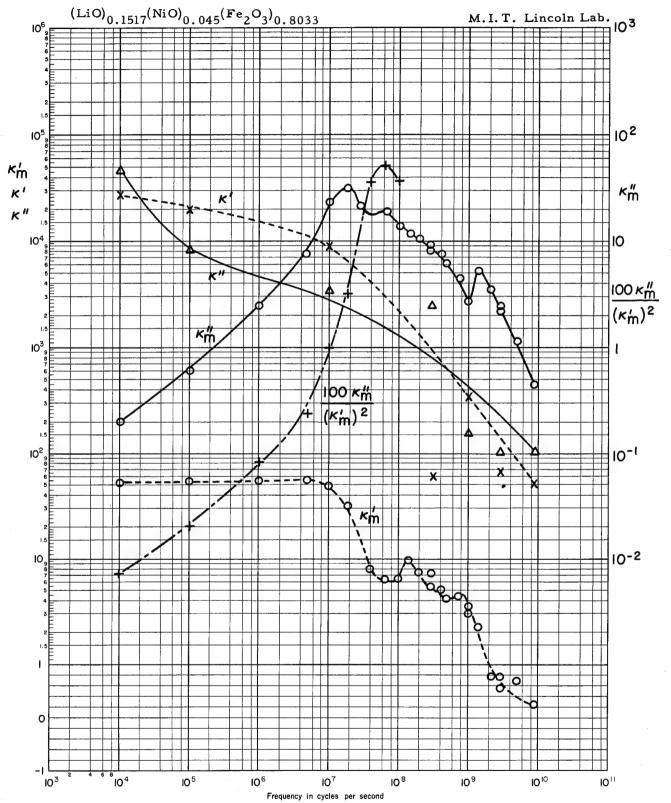


IV A 1. Nickel Ferrite, Single Crystal

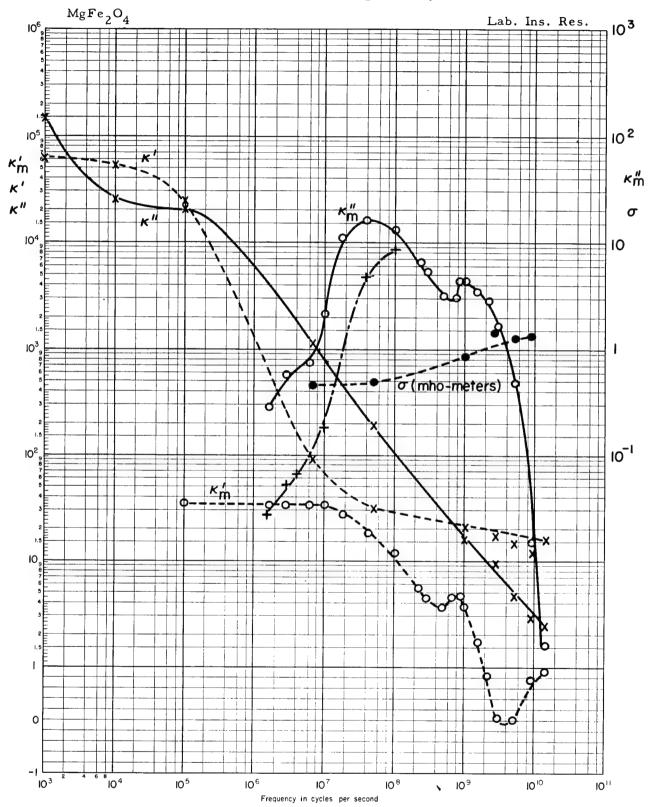




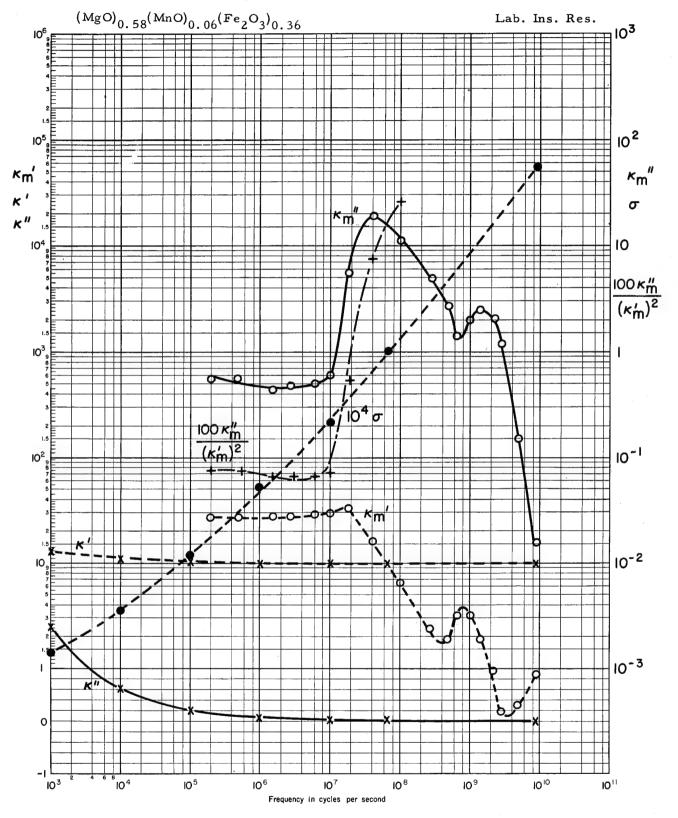
IV A 3. Lithium-Nickel Ferrite Ceramic



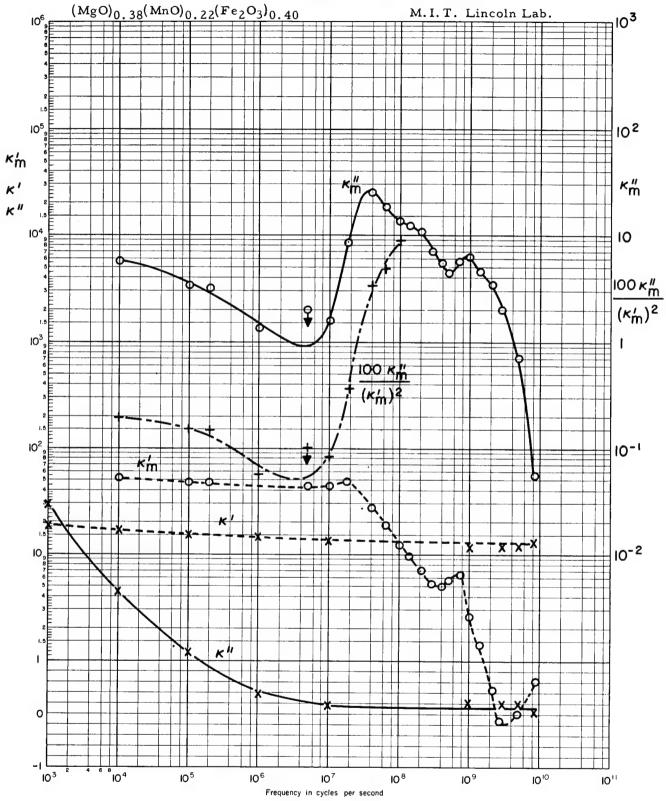
IV A 4. Magnesium Ferrite, High Density Ceramic



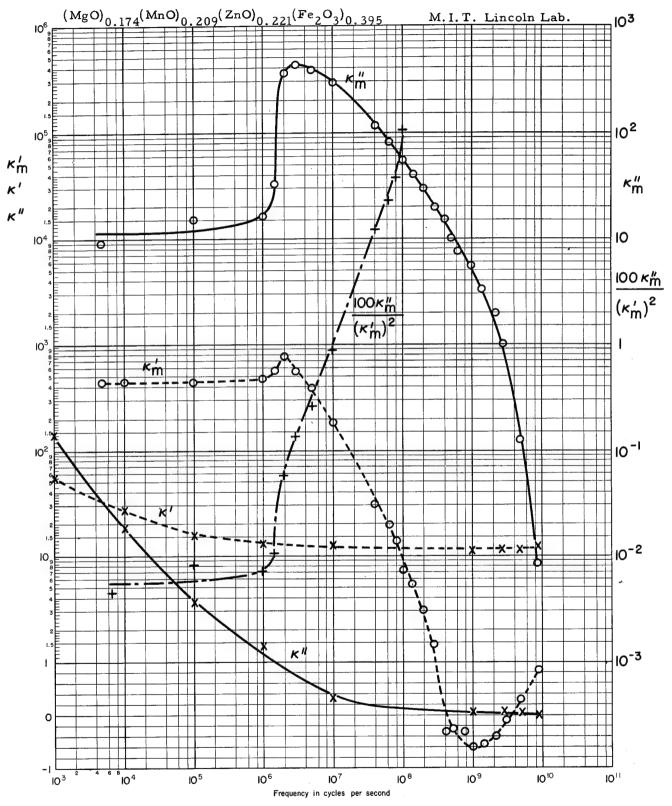
IV A 5. Magnesium Manganese Ferrite Ceramics



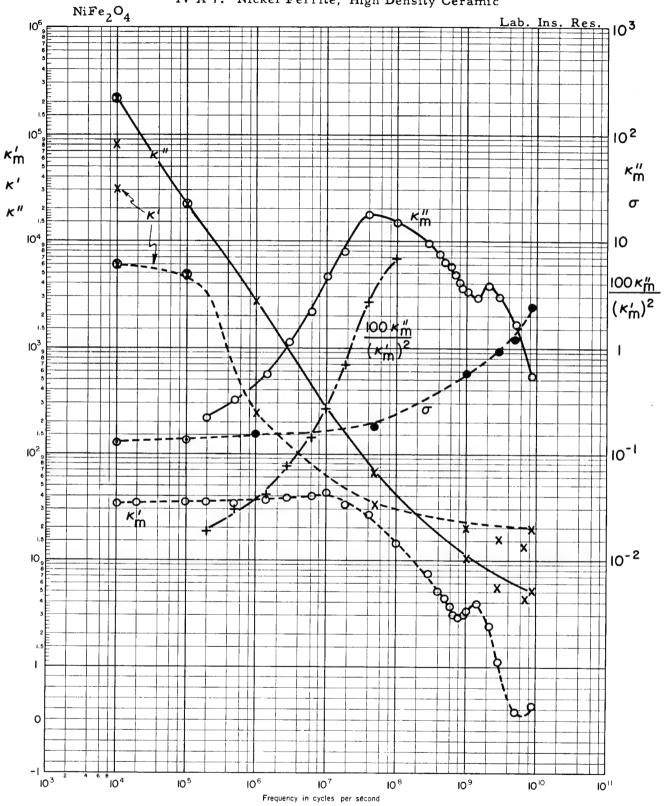
IV A 5. Magnesium-Manganese Ferrite Ceramics



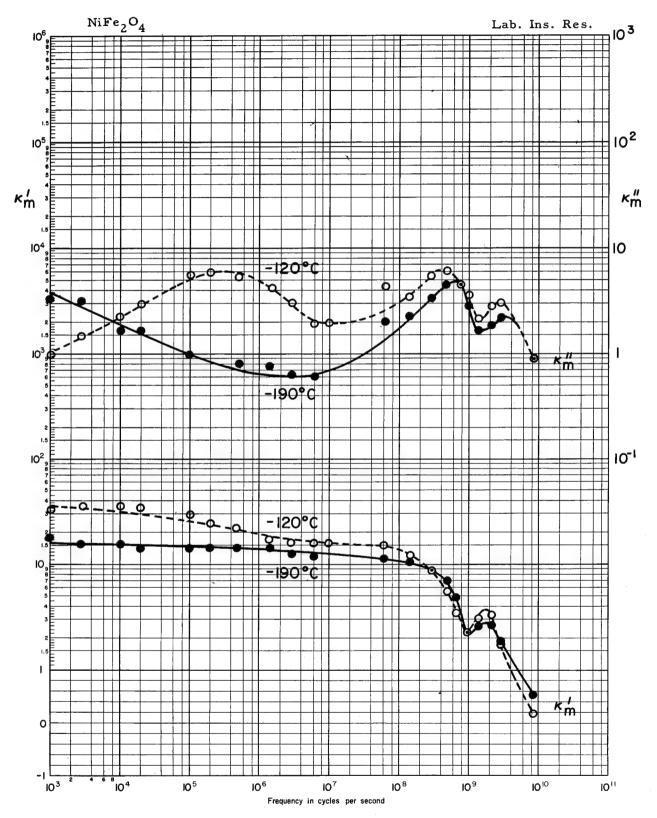
IV A 6. Magnesium-Manganese-Zinc Ferrite Ceramic



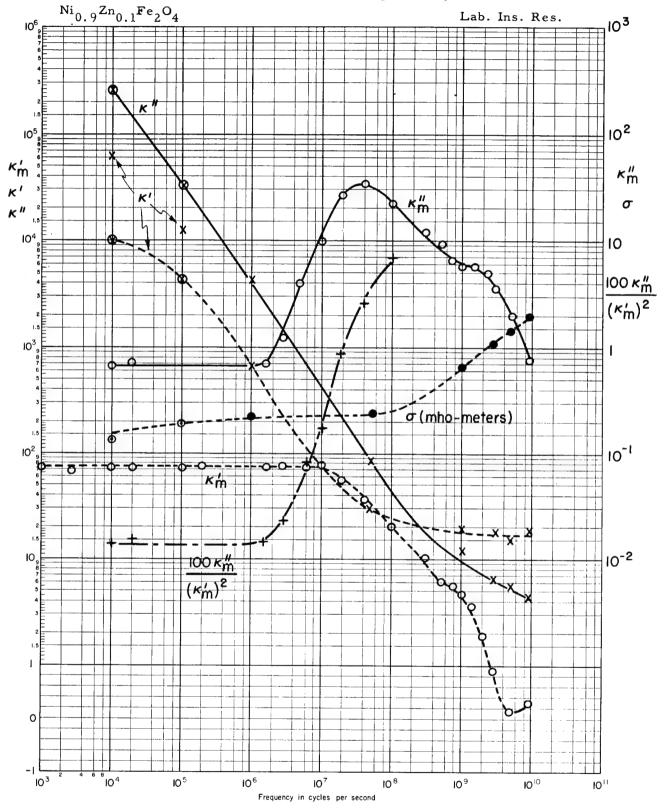
IV A 7. Nickel Ferrite, High Density Ceramic



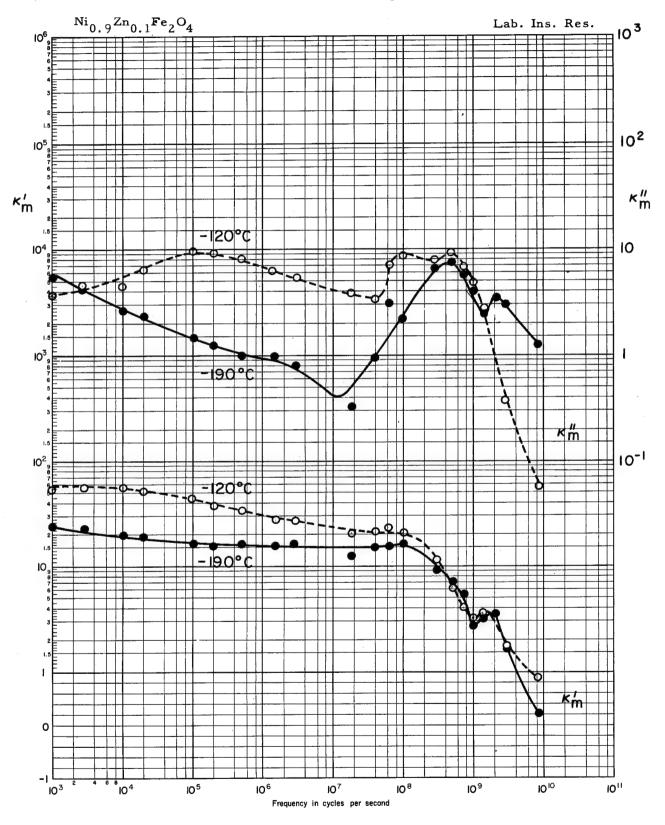
IV A 7. Nickel Ferrite, High Density Ceramic



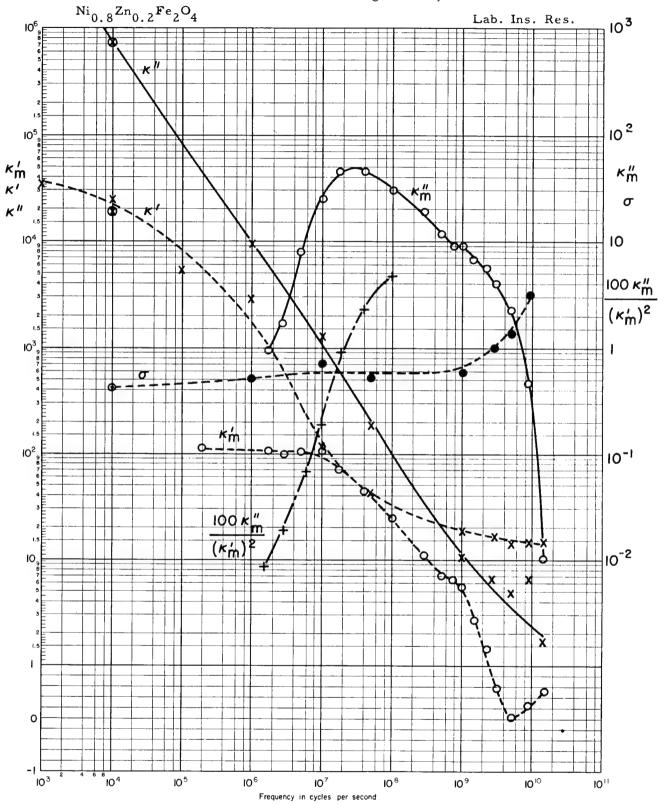
IV A 8. Nickel-Zinc Ferrites, High Density Ceramics



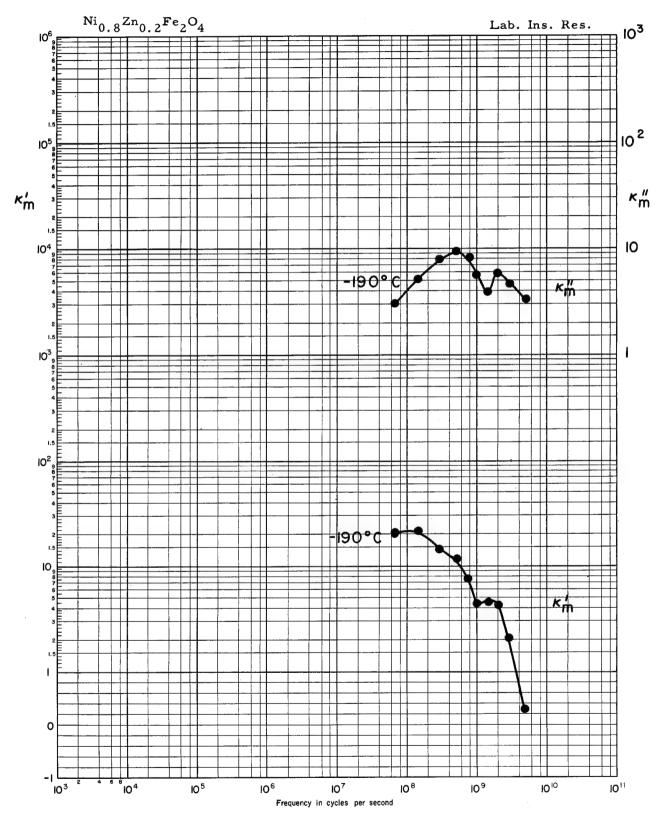
IV A 8. Nickel-Zinc Ferrites, High Density Ceramics

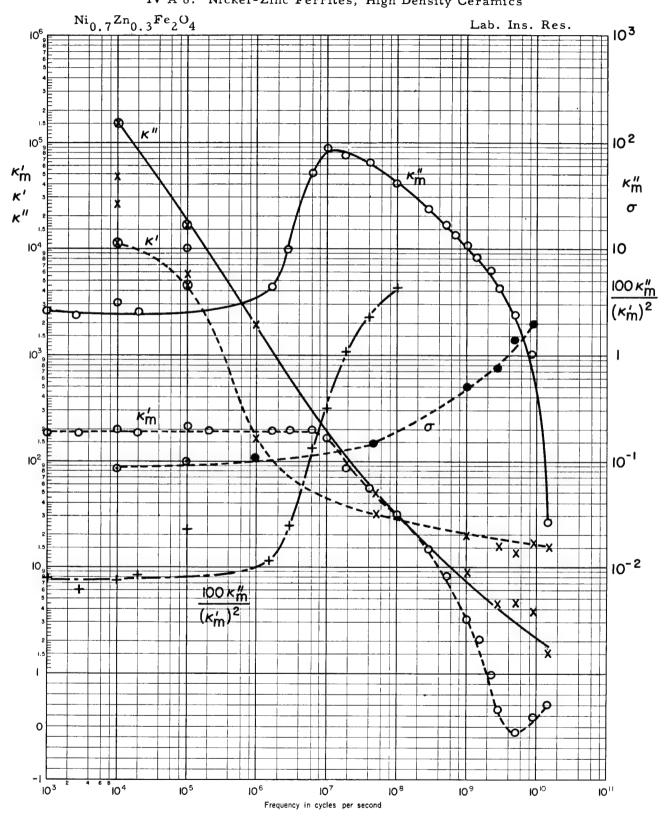


- 146 - IV A 8. Nickel-Zinc Ferrites, High Density Ceramics

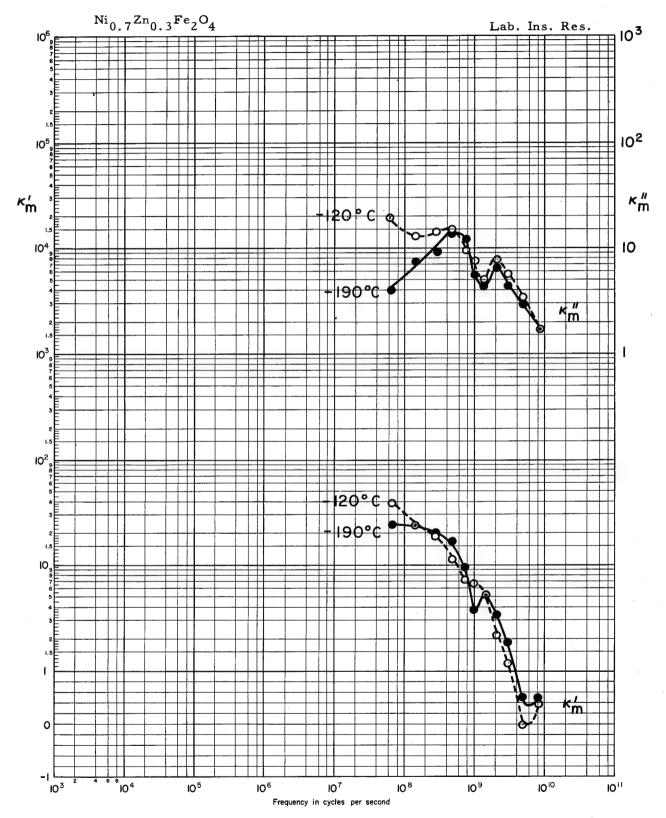


IV A 8. Nickel-Zinc Ferrites, High Density Ceramics

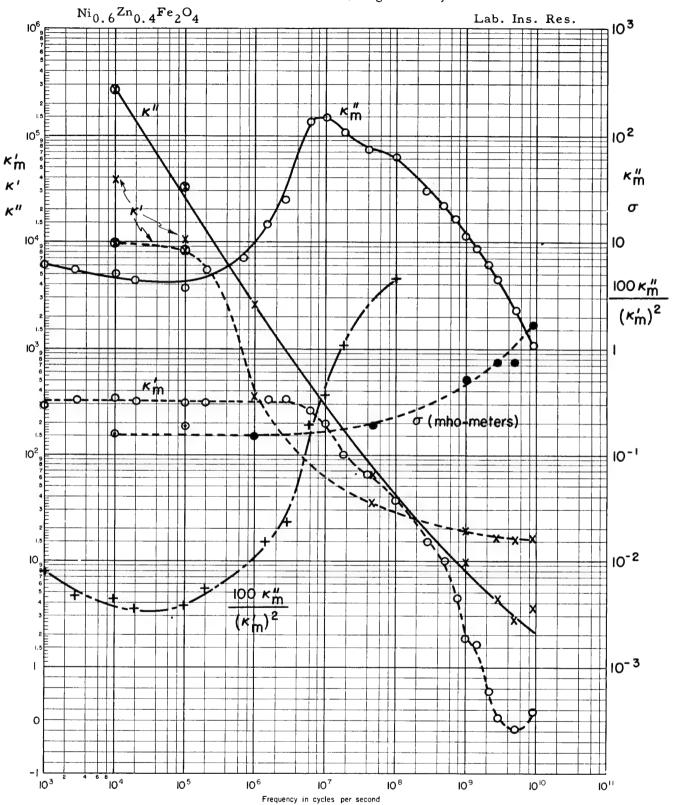




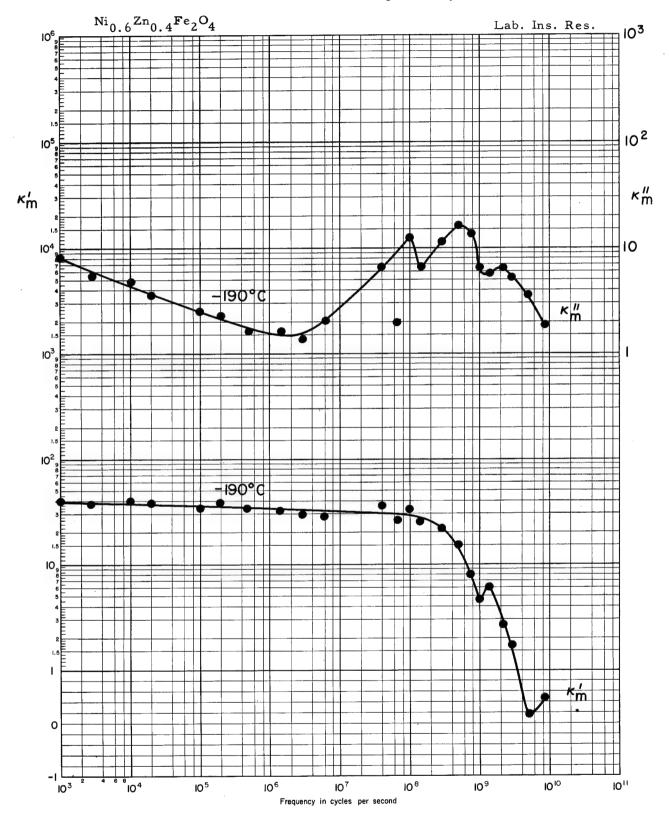
IV A 8. Nickel-Zinc Ferrites, High Density Ceramics



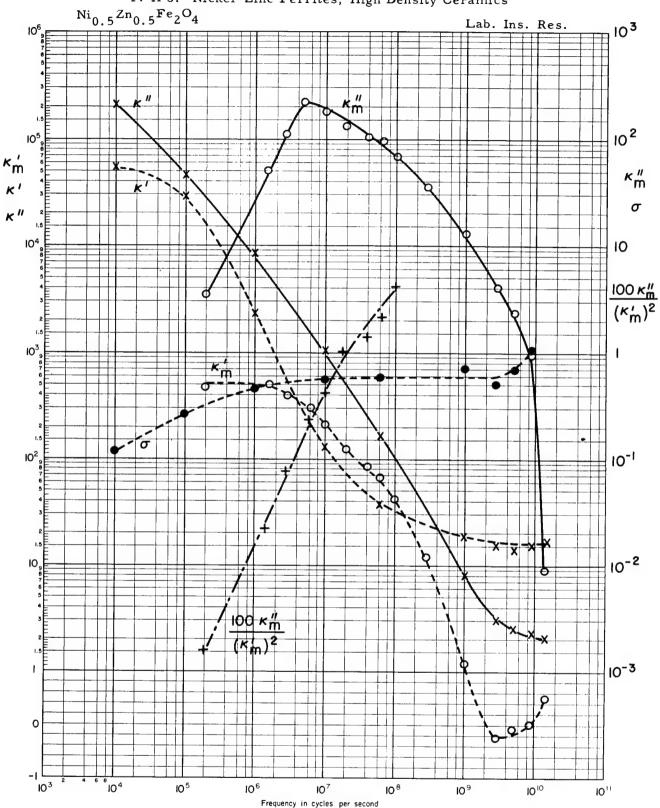
IV A 8. Nickel-Zinc Ferrites, High Density Ceramics



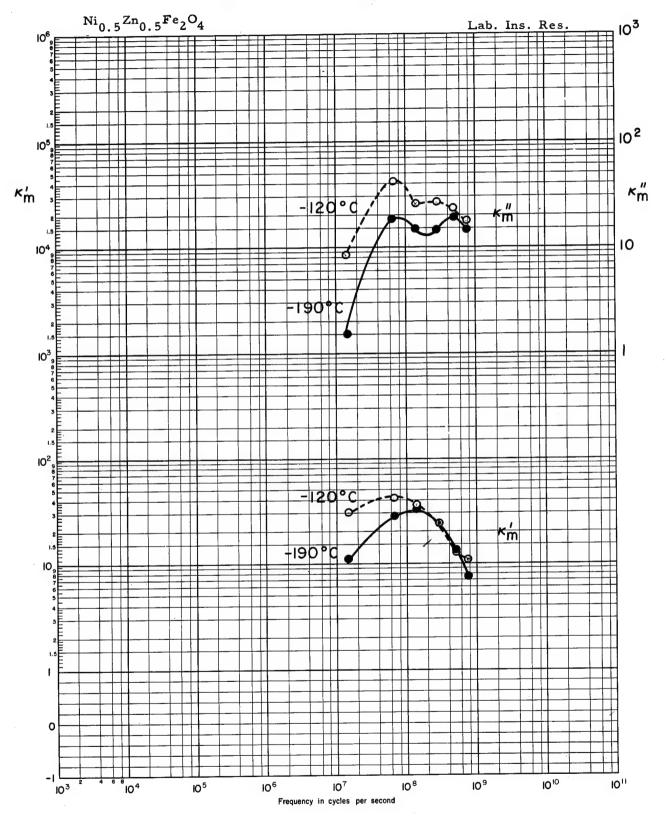
IV A 8. Nickel-Zinc Ferrites, High Density Ceramics



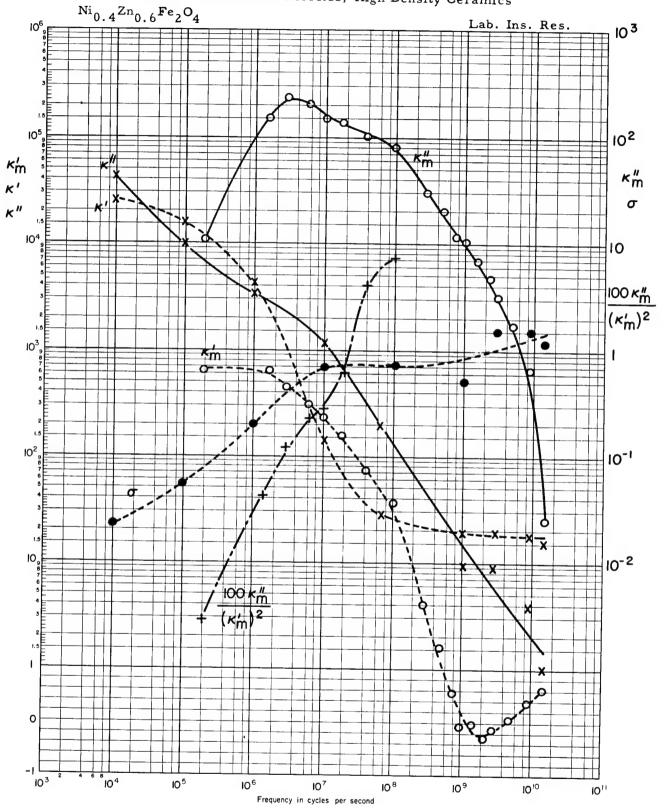
- 152 - IV A 8. Nickel-Zinc Ferrites, High Density Ceramics



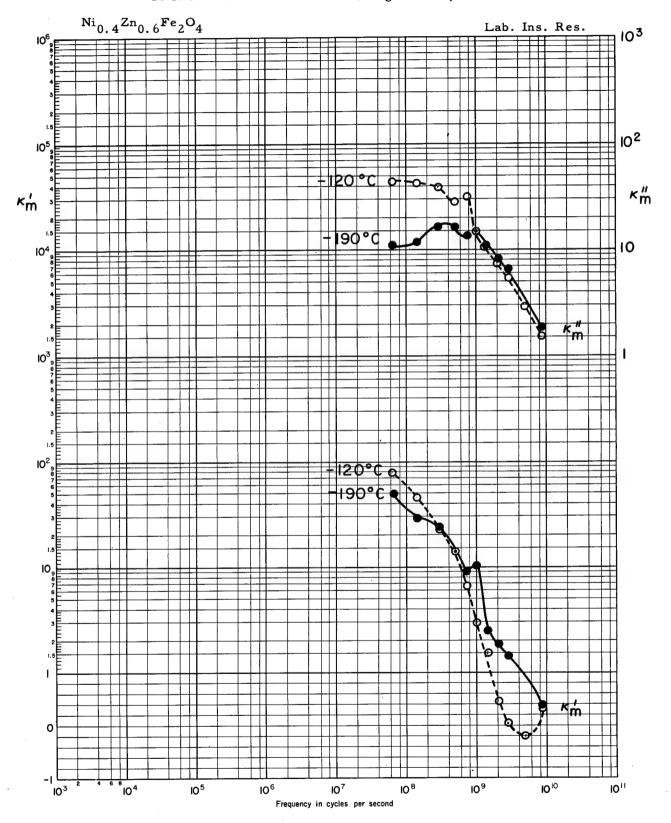
IV A.8. Nickel-Zinc Ferrites, High Density Ceramics



- 154 - IV A 8. Nickel-Zinc Ferrites, High Density Ceramics

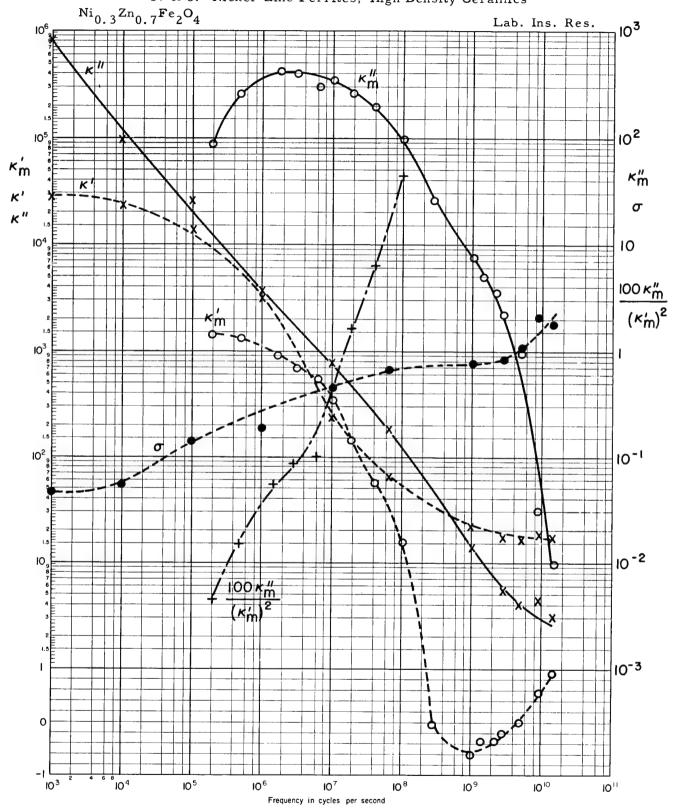


IV A 8. Nickel-Zinc Ferrites, High Density Ceramics

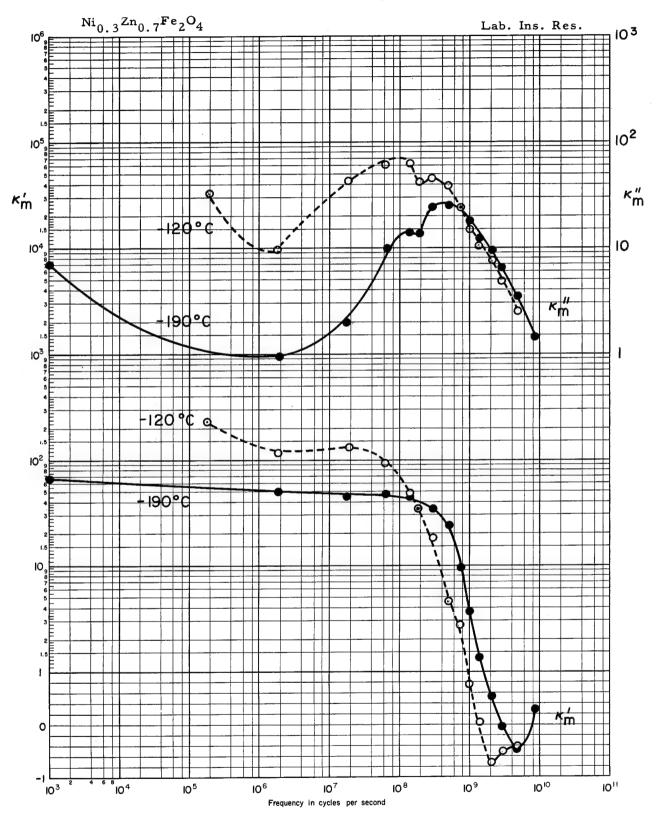


- 156 -

IV A 8. Nickel-Zinc Ferrites, High Density Ceramics

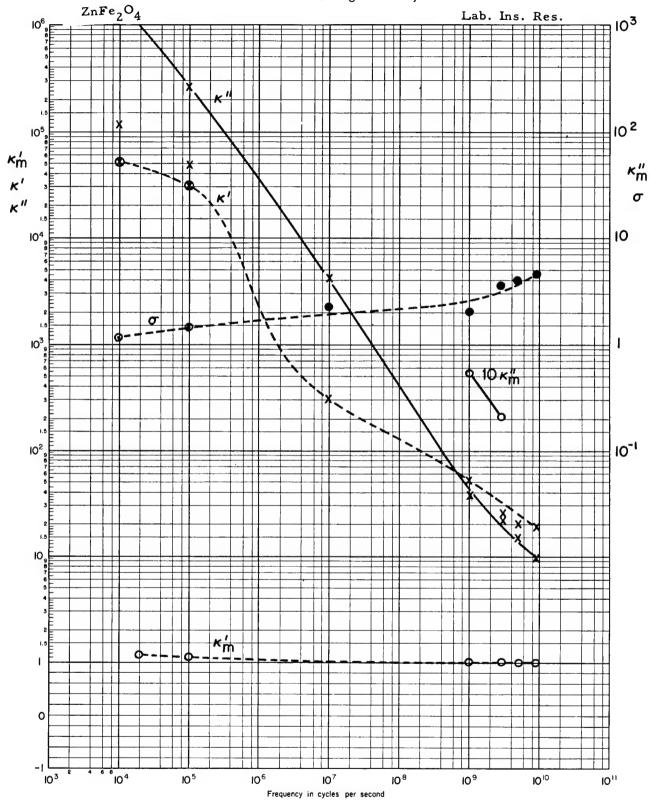


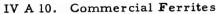
IV A 8. Nickel-Zinc Ferrites, High Density Ceramics

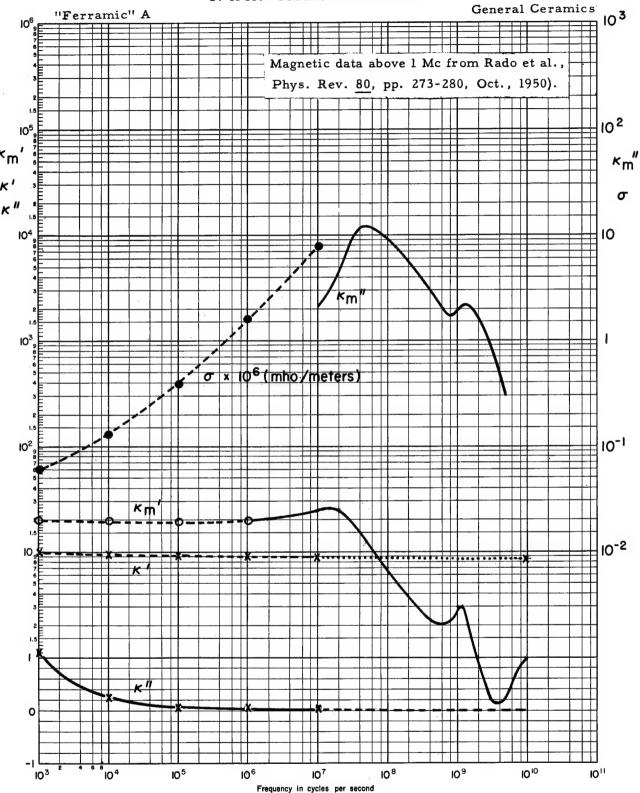


- 158 -

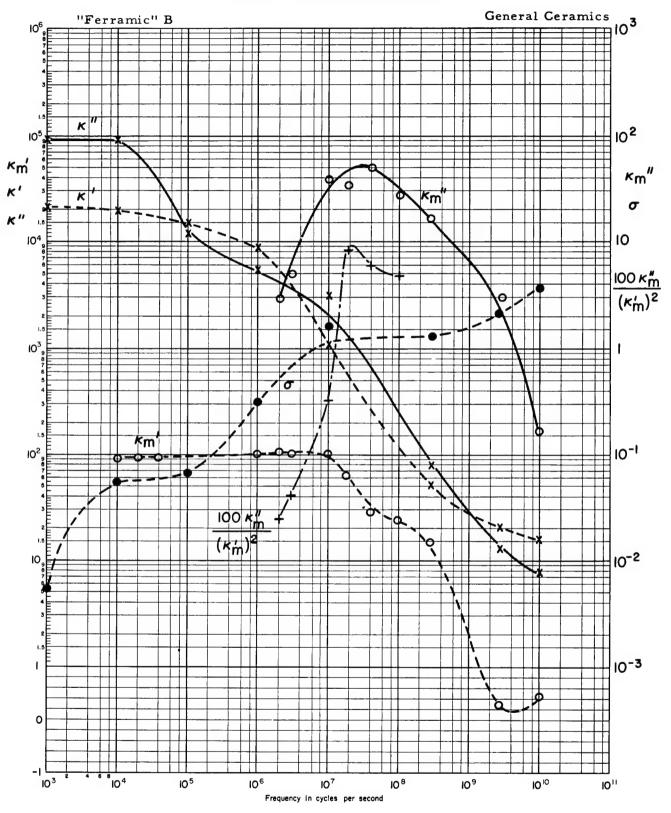
IV A 9. Zinc Ferrite, High Density Ceramic



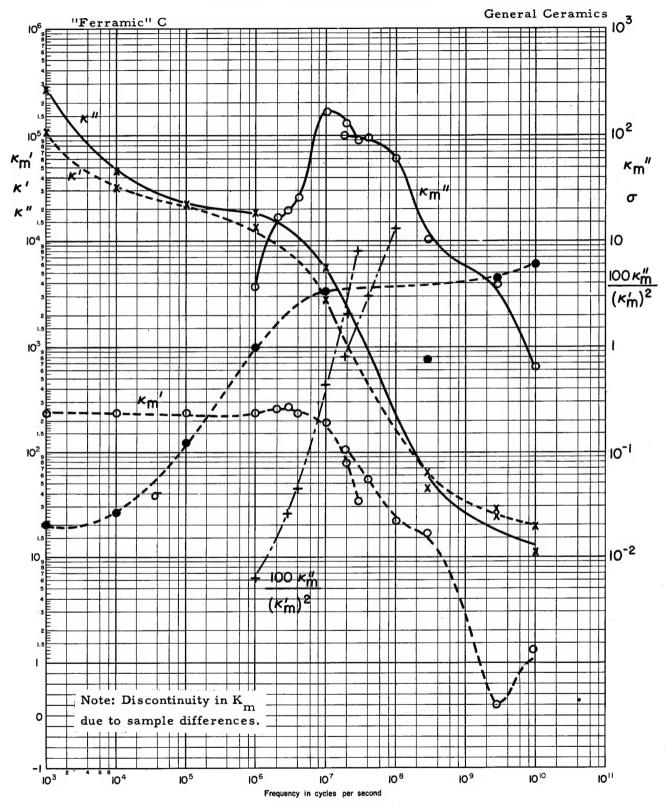




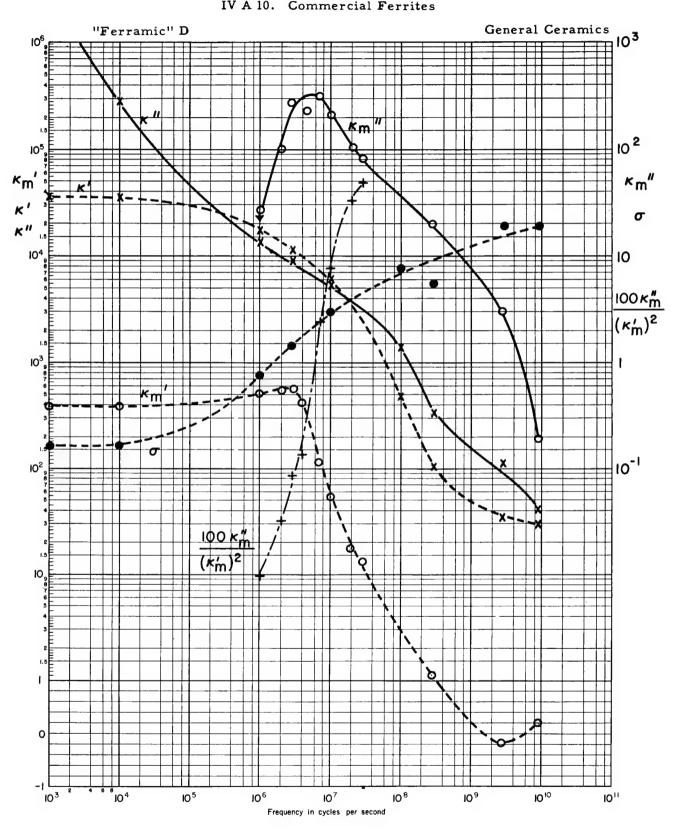
IV A 10. Commercial Ferrites

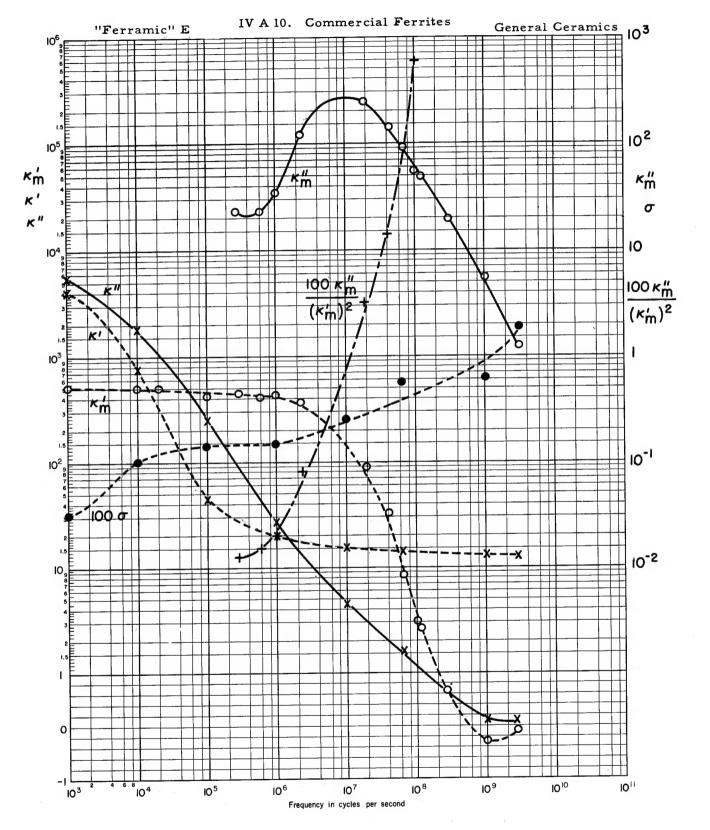


IV A 10. Commercial Ferrites

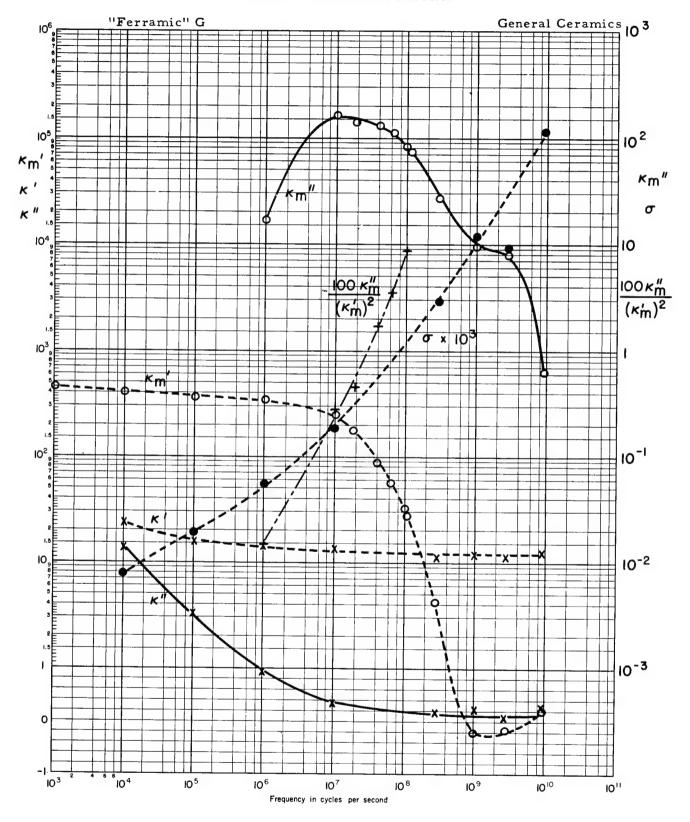


IV A 10. Commercial Ferrites

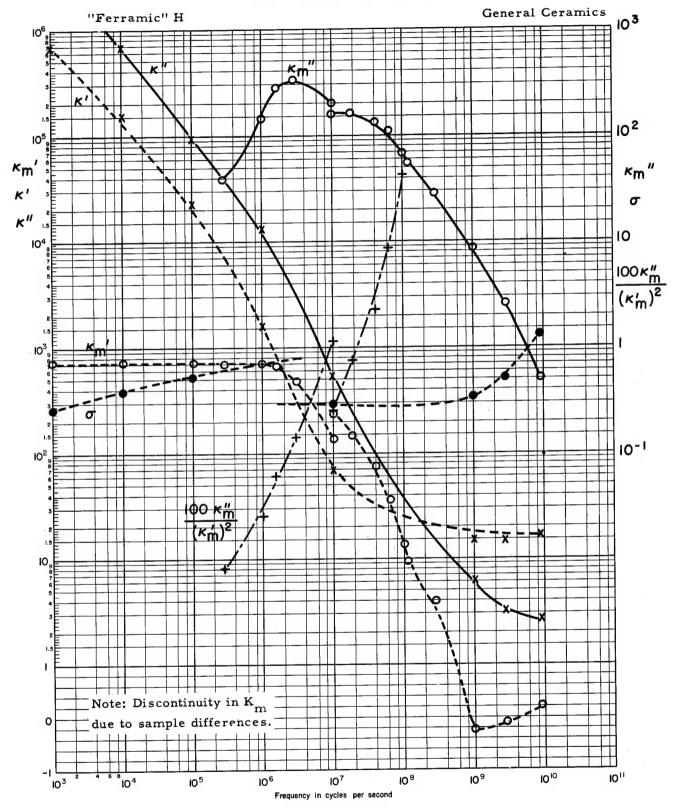




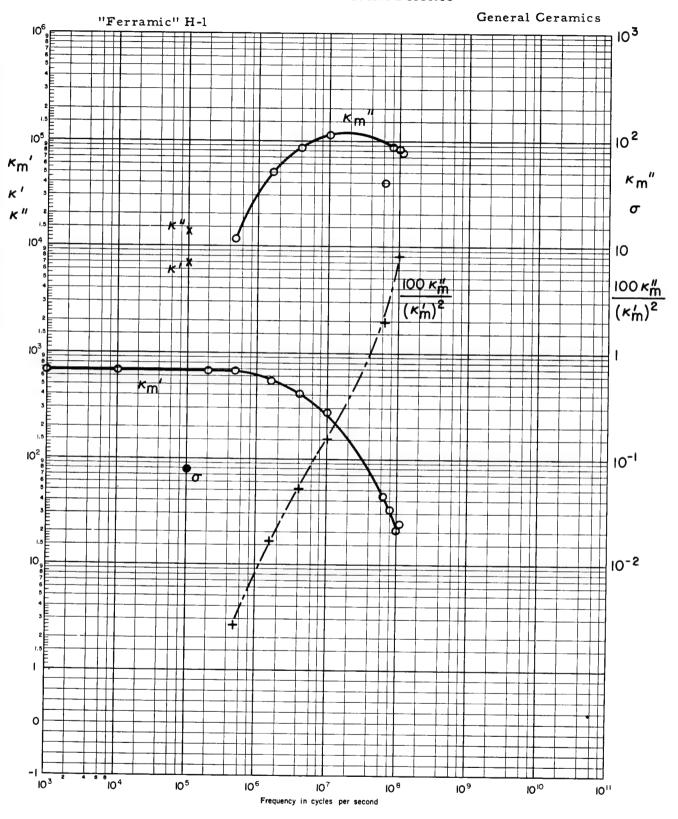
IV A 10. Commercial Ferrites



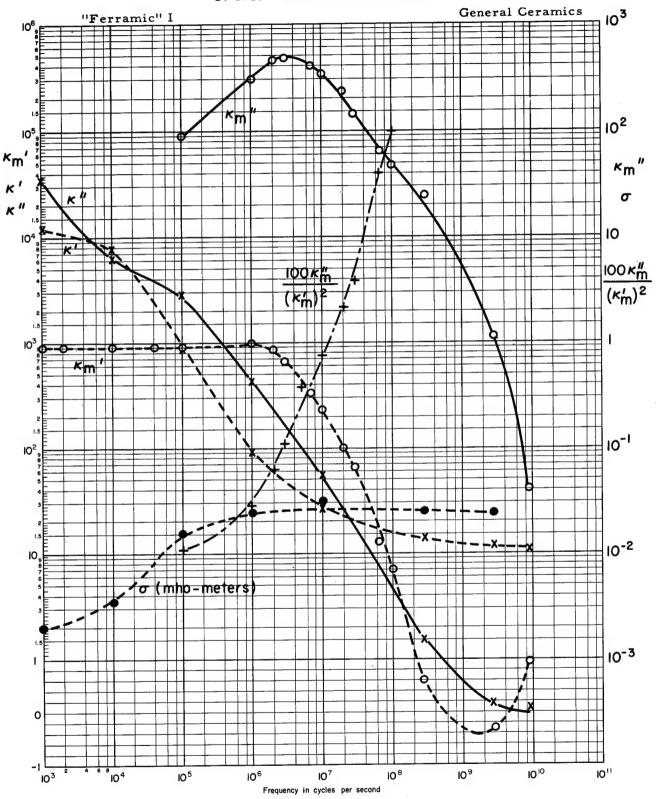
IV A 10. Commercial Ferrites



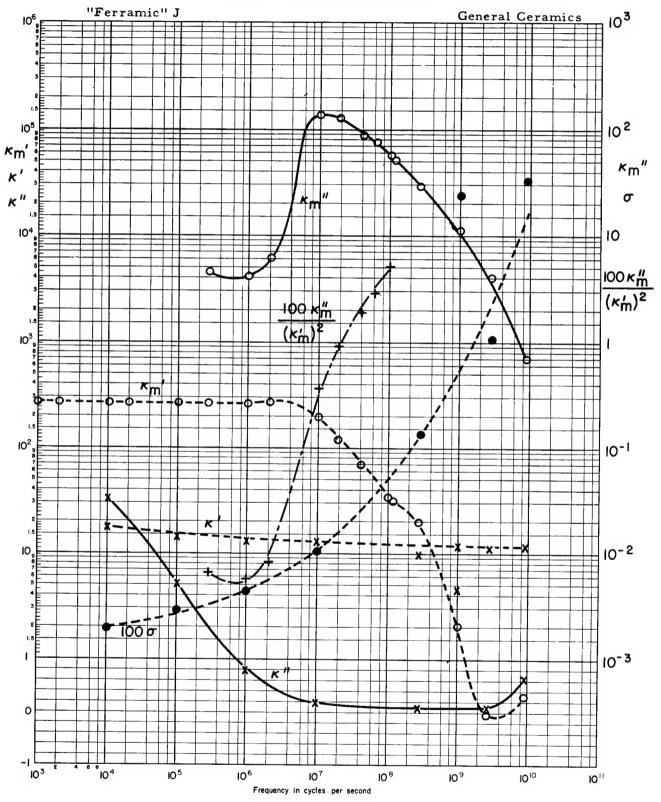
IV A 10. Commercial Ferrites



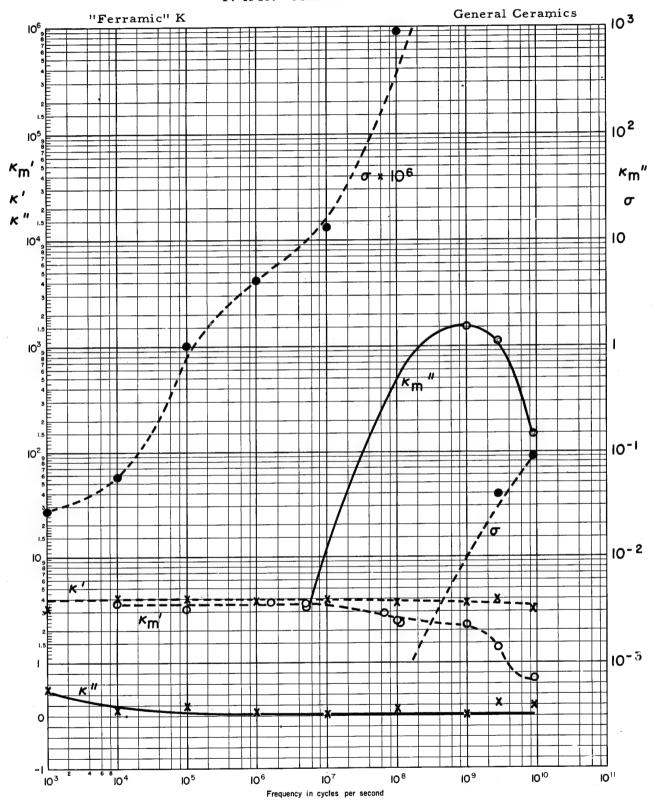
IV A 10. Commercial Ferrites



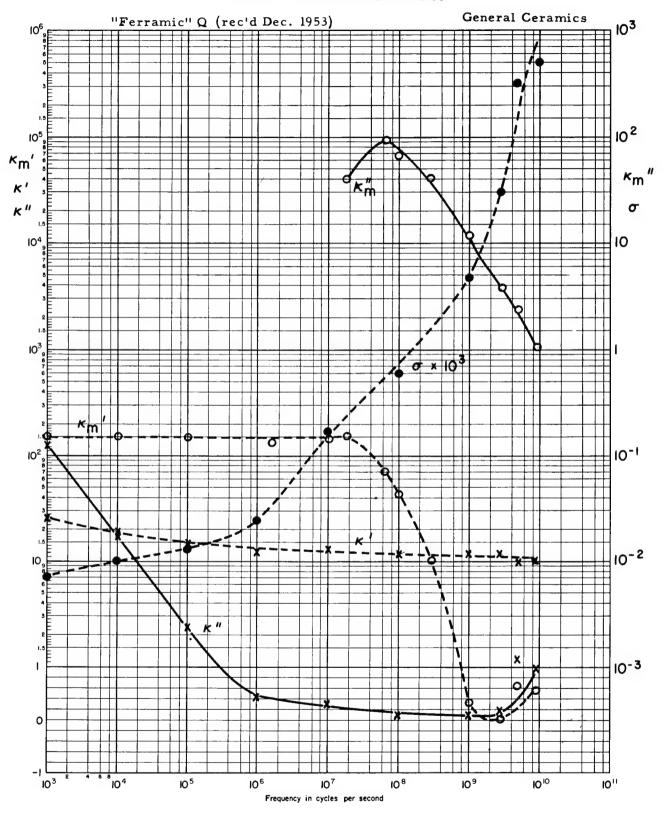
IV A 10. Commercial Ferrites

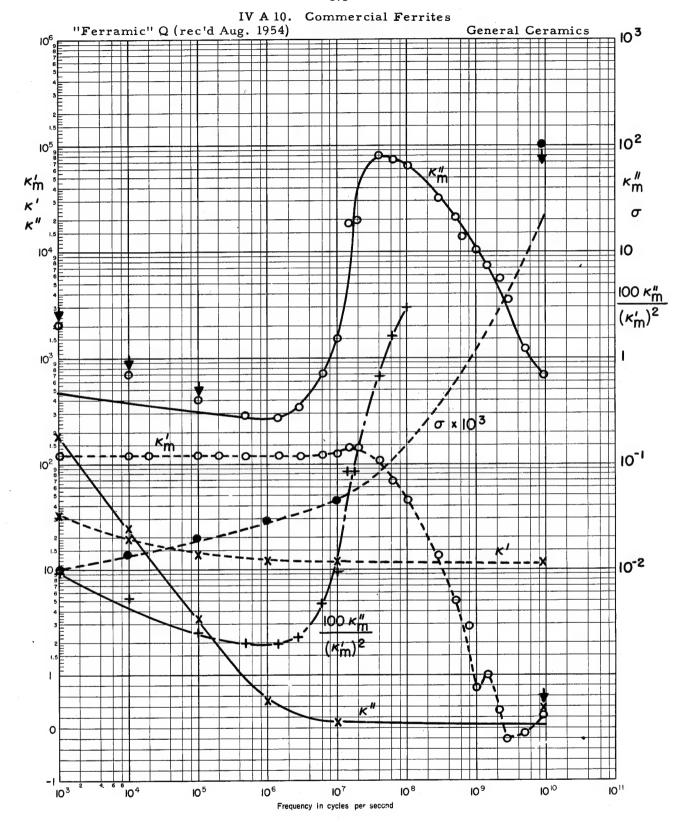


IV A 10. Commercial Ferrites

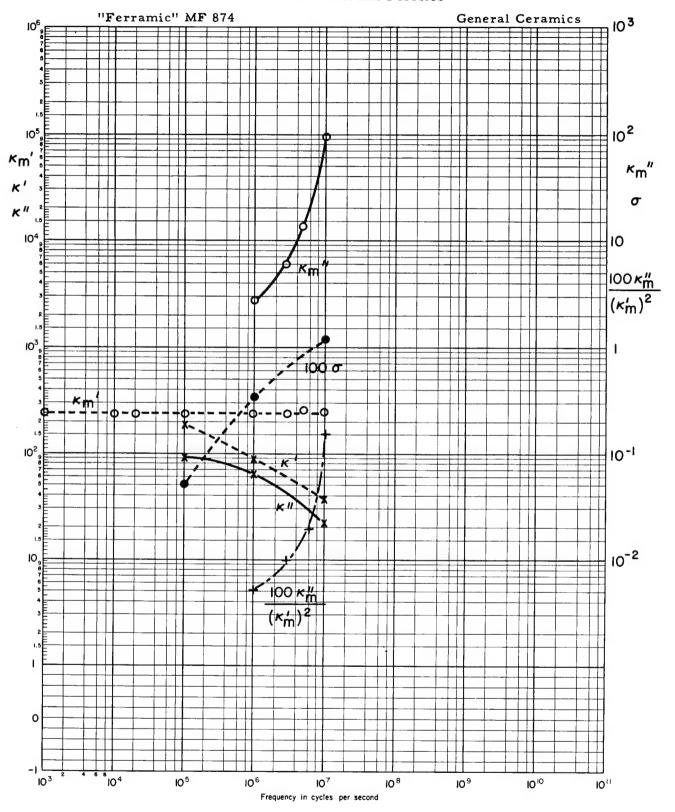


IV A 10. Commercial Ferrites

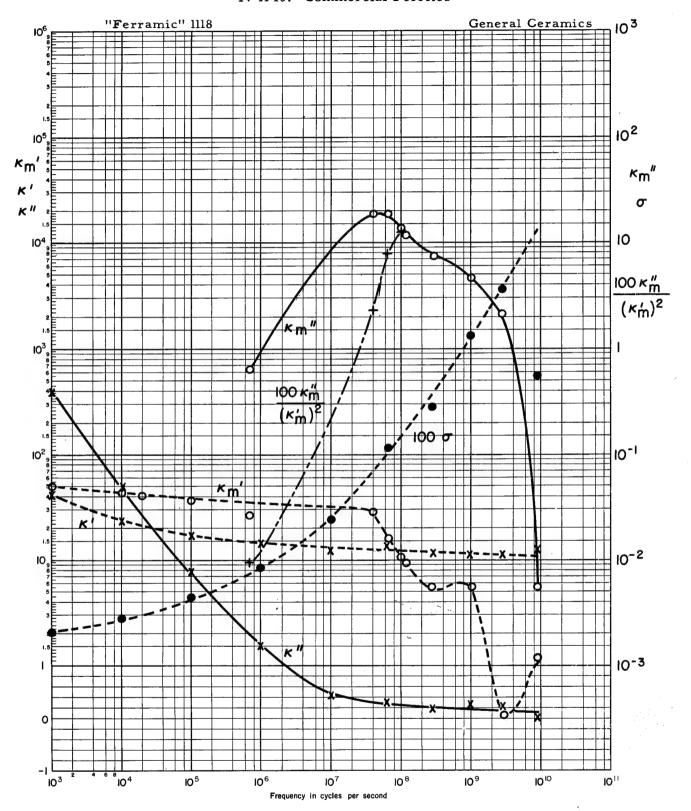




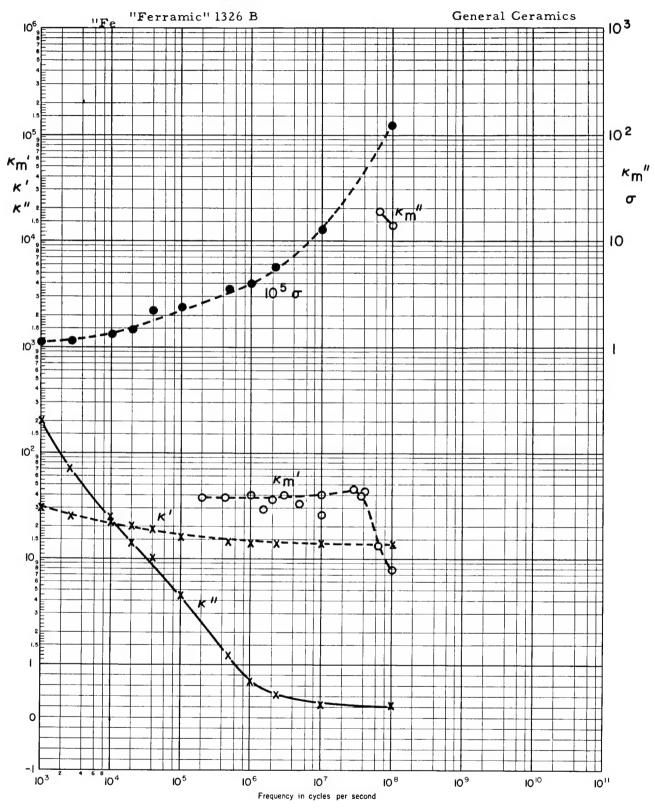
IV A 10. Commercial Ferrites



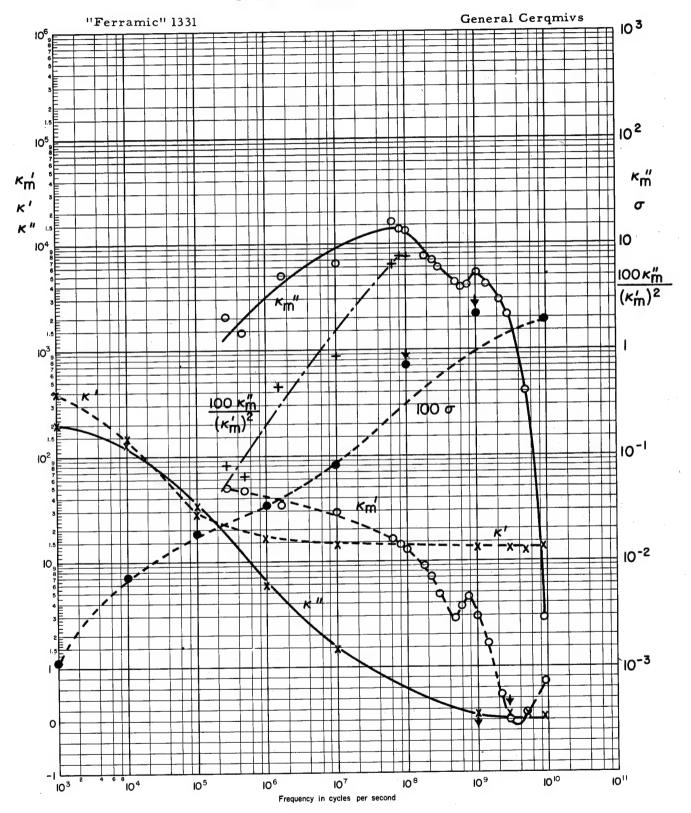
IV A 10. Commercial Ferrites

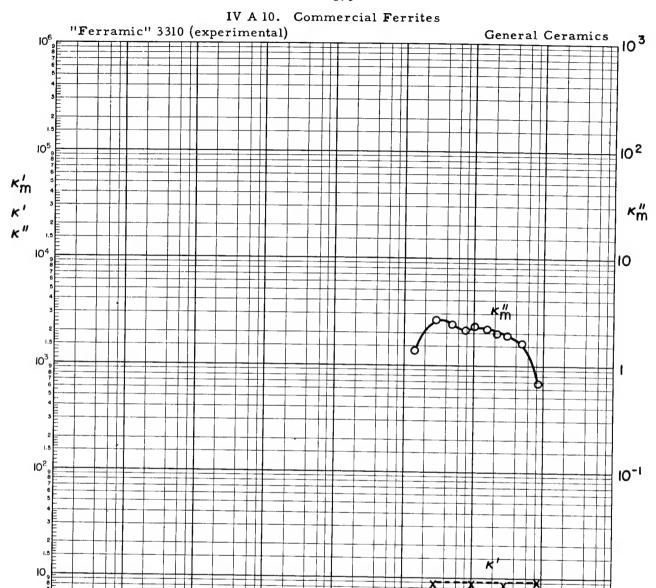


IV A 10. Commercial Ferrites



IV A 10. Commercial Ferrites





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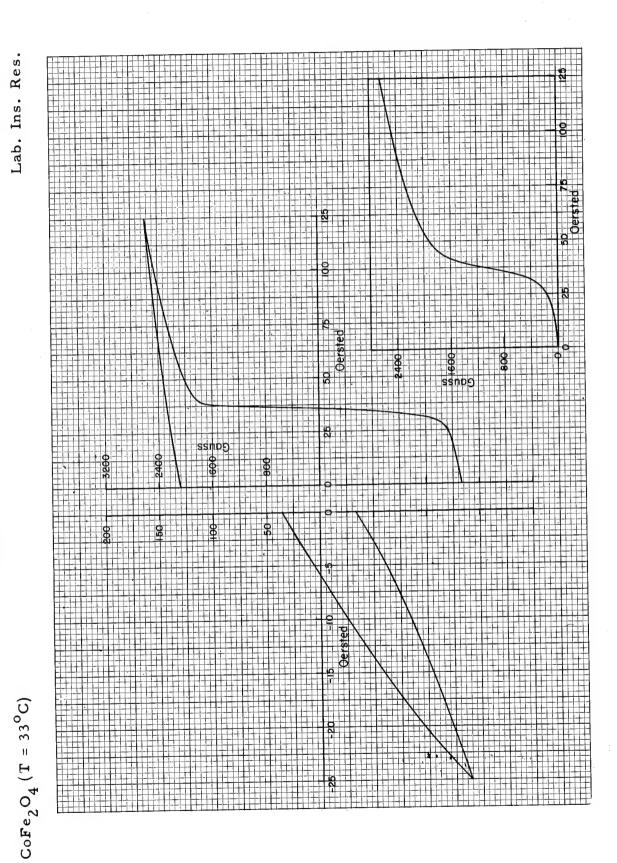
1011

107

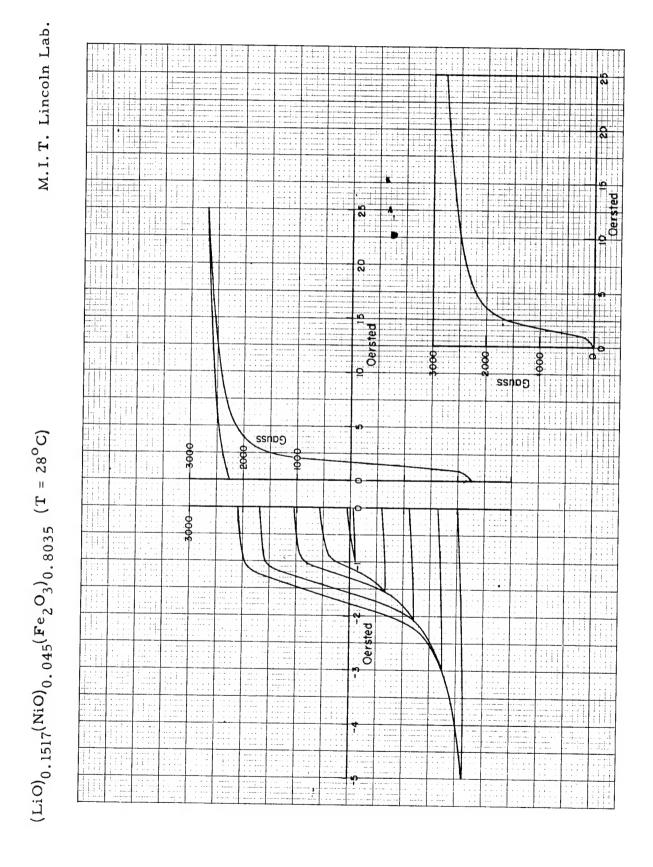
Frequency in cycles per second

IV B. Hysteresis Loops and Saturation Magnetization

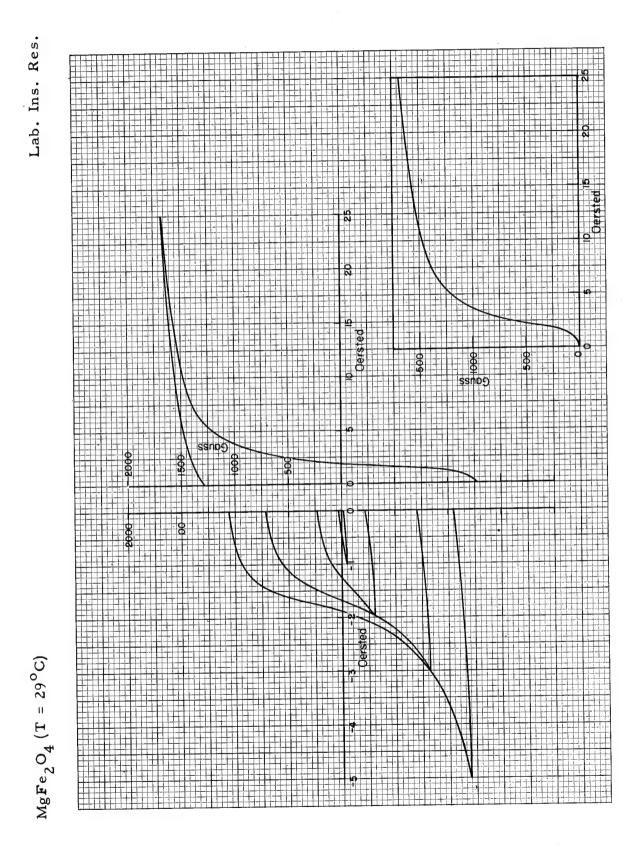
1. Cobalt Ferrite, High Density Ceramic



IV B 2. Lithium-Nickel Ferrite Ceramic

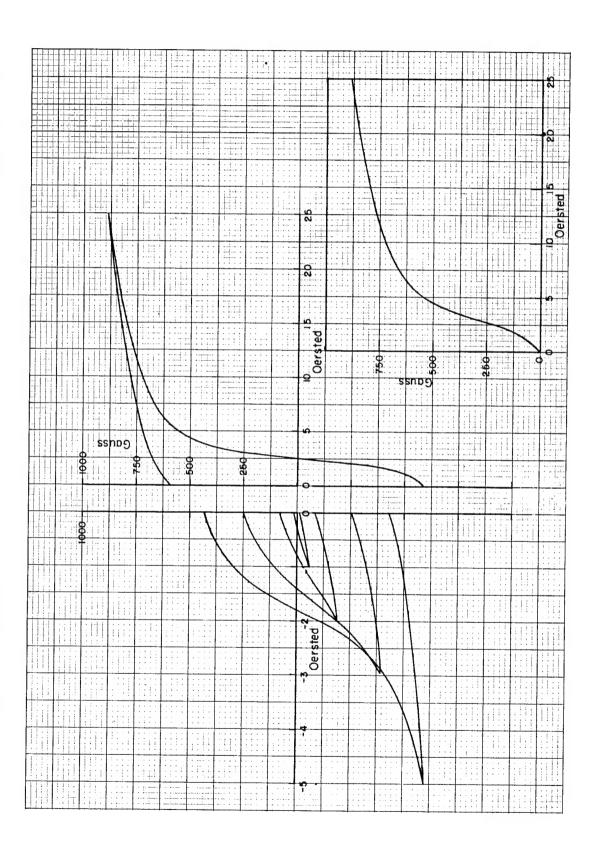


IV B 3. Magnesium Ferrite, High Density Ceramic

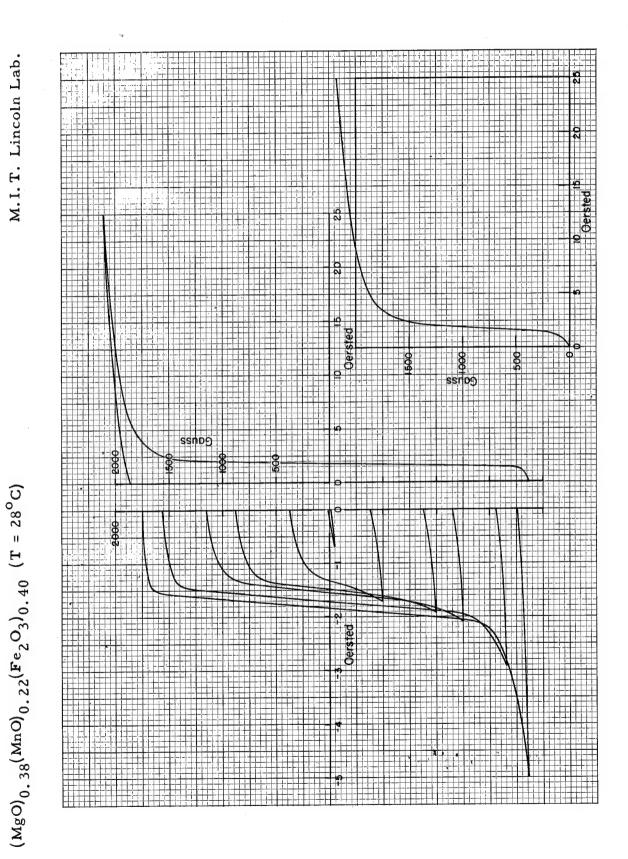


IV B 4. Magnesium-Manganese Ferrite Ceramics



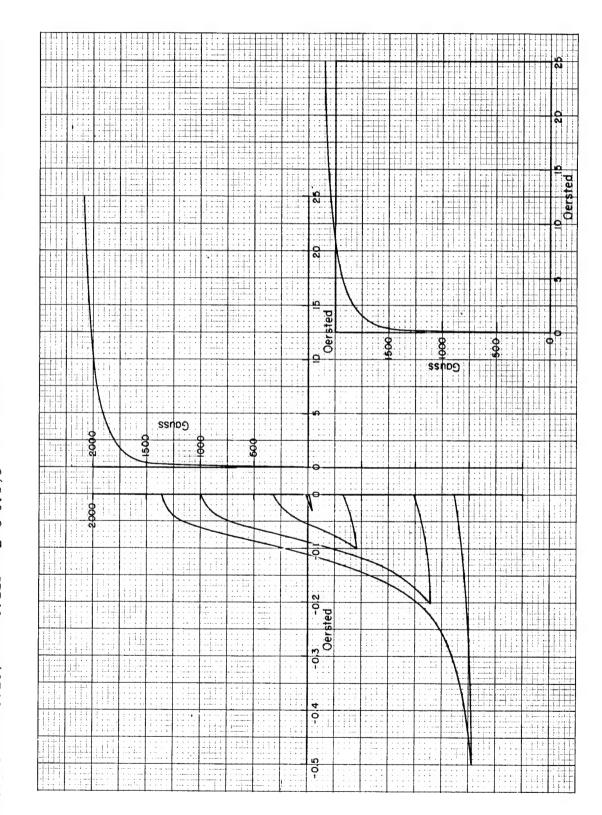


IV B 4. Magnesium-Manganese Ferrite Ceramics

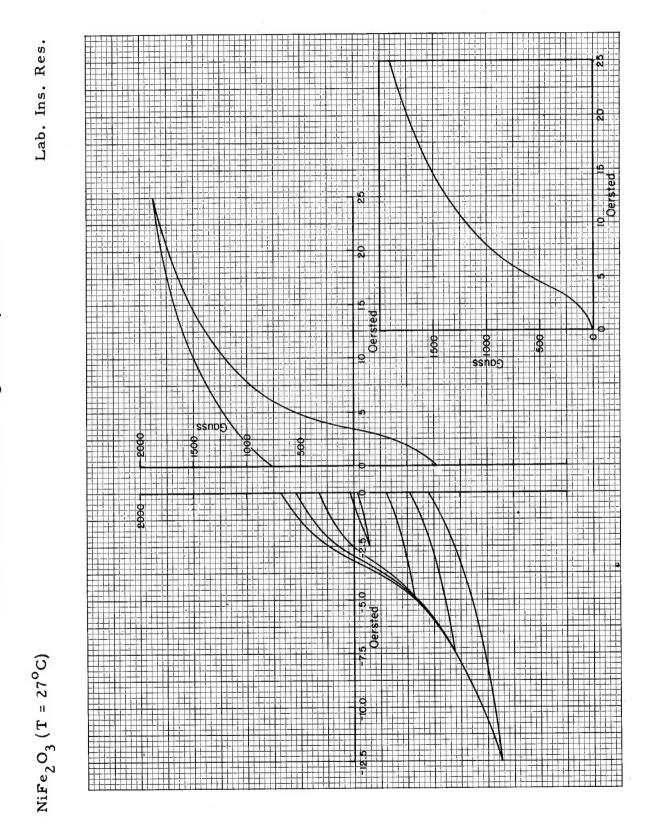


IV B 5. Magnesium-Manganese-Zinc Ferrite Ceramic

M.I.T. Lincoln Lab. $(MgO)_{0.174}(MnO)_{0.209}(ZnO)_{0.221}(Fe_2O_3)_{0.395}$ (T = 28°C)



IV B 6. Nickel Ferrite, High Density Ceramic

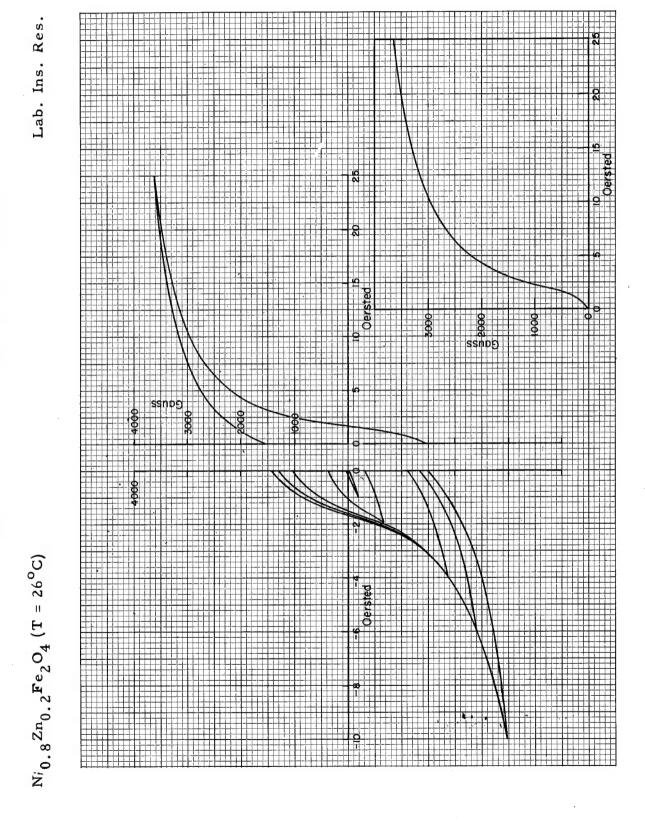


IV B 7. Nickel-Zinc Ferrite, High Density Ceramics

 $Ni_{0.9}^{Z}n_{0.1}^{F}e_{2}^{O_{4}}(T = 26^{O}C)$

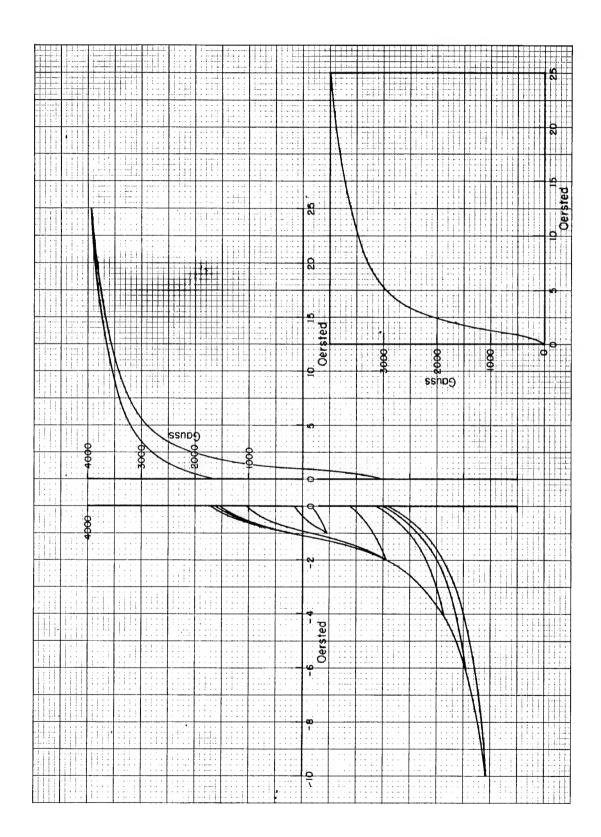
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IV B 7. Nickel-Zinc Ferrite, High Density Ceramics



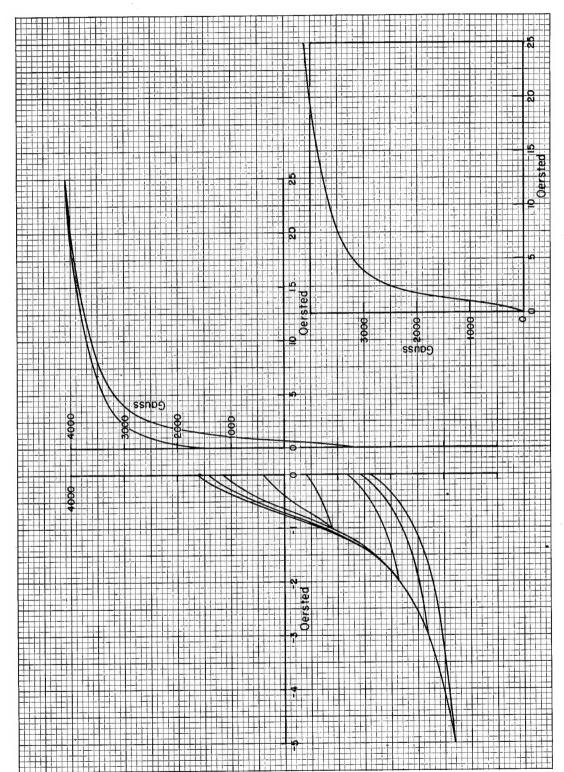
IV B 7. Nickel-Zinc Ferrite, High Density Ceramics





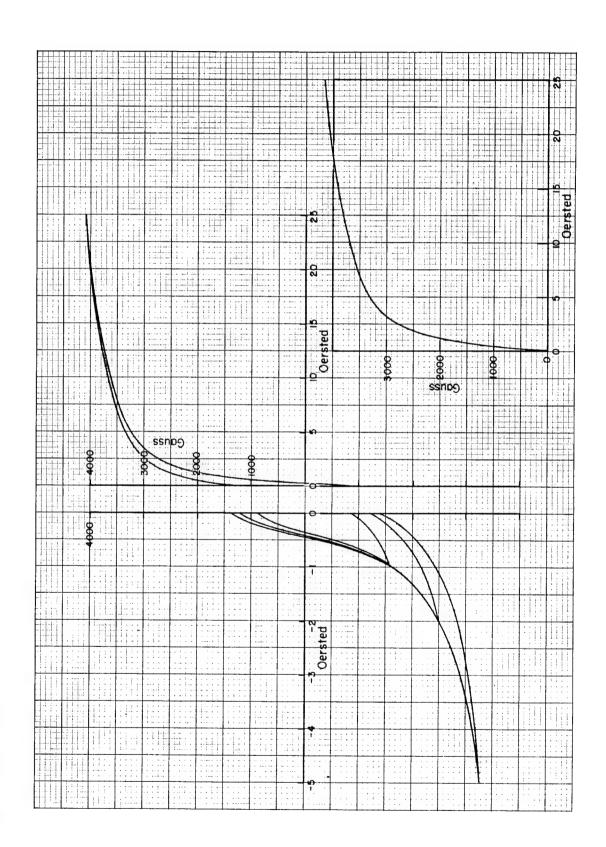
IV B 7. Nickel-Zinc Ferrite, High Density Geramics





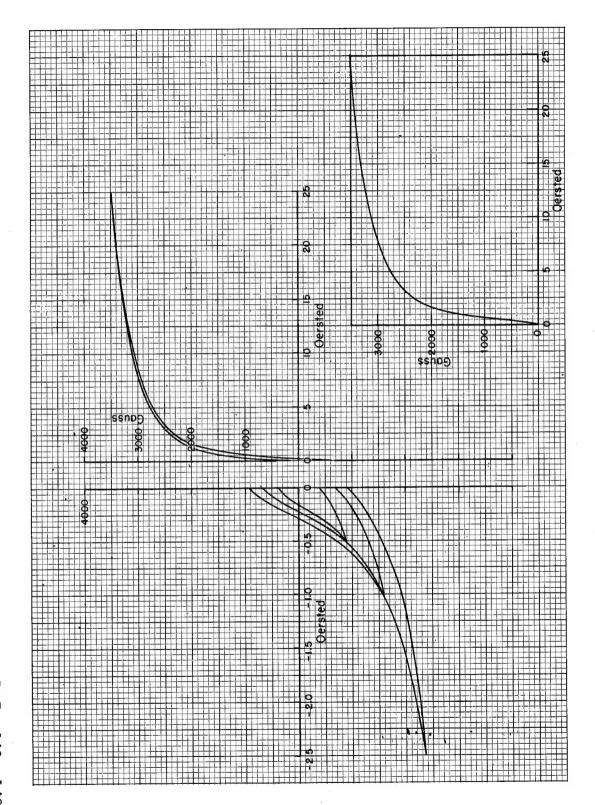
IV B 7. Nickel-Zinc Ferrite, High Density Ceramics





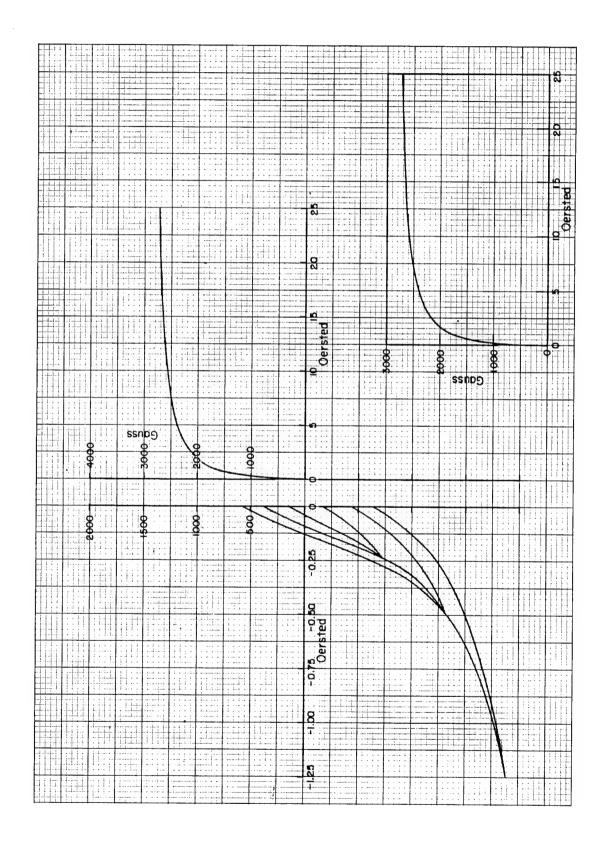
IV B 7. Nickel-Zinc Ferrite, High Density Ceramics



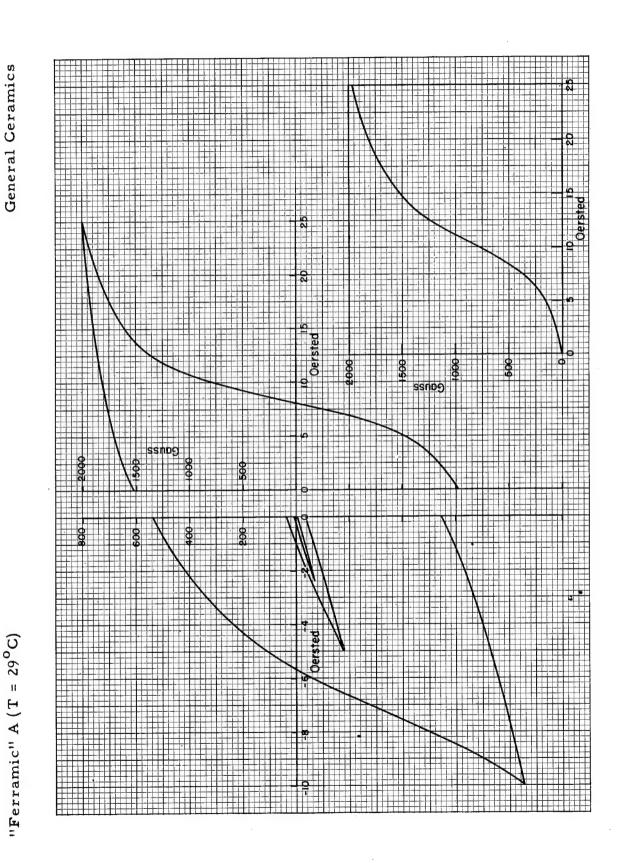


IV B 7. Nickel-Zinc Ferrite, High Density Ceramics

 $Ni_{0.3}Zn_{0.7}Fe_2O_4$ (T = 29°C)

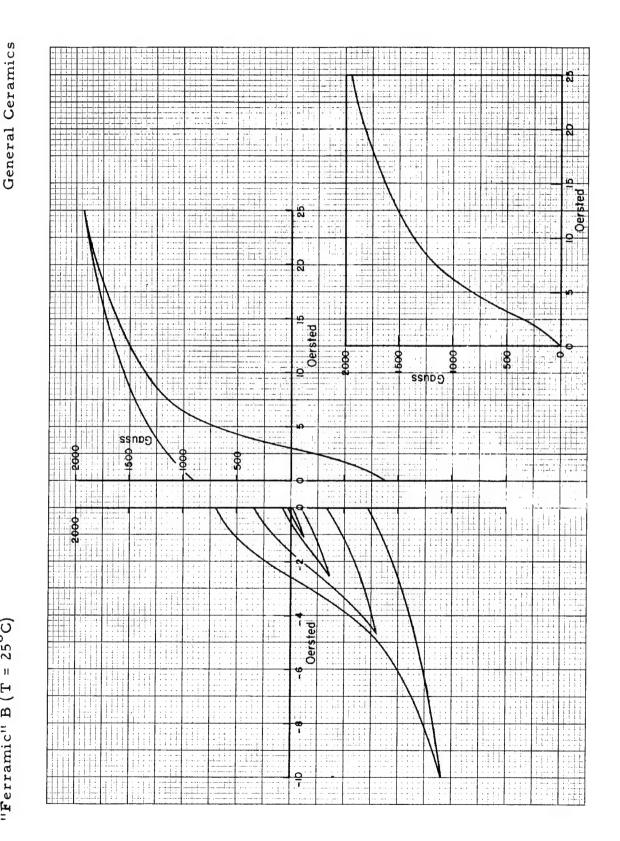


IV B 8. Commercial Ferrite Ceramics

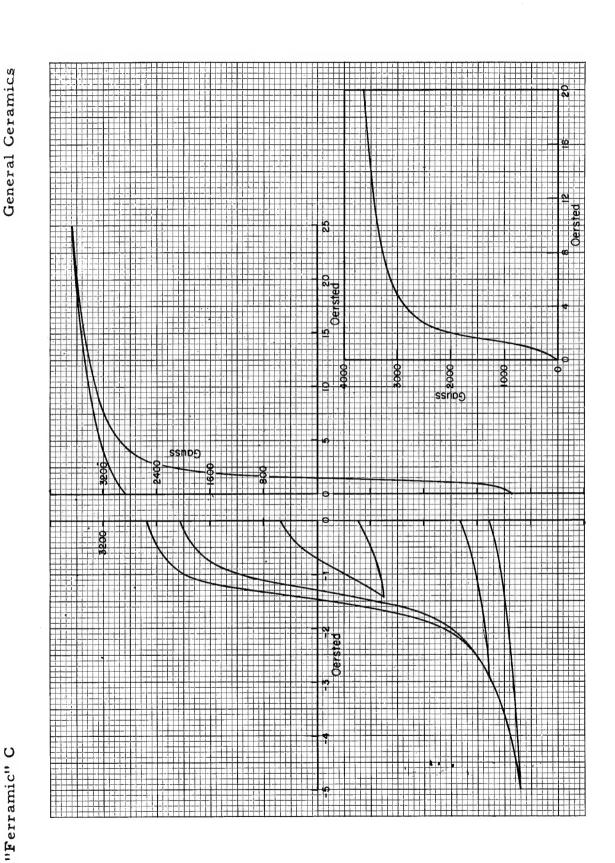


Commercial Ferrite Ceramics IVB8.

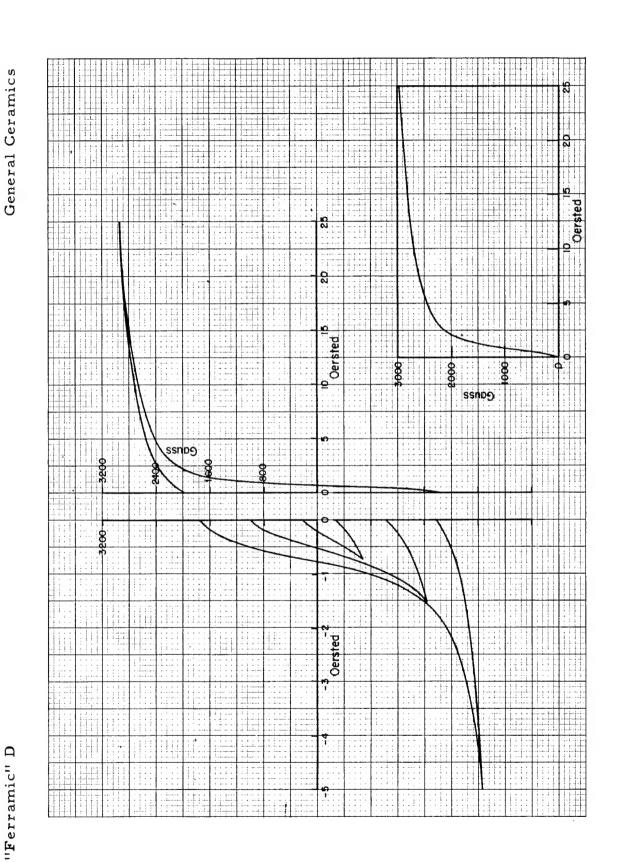
"Ferramic" $B(T = 25^{\circ}C)$



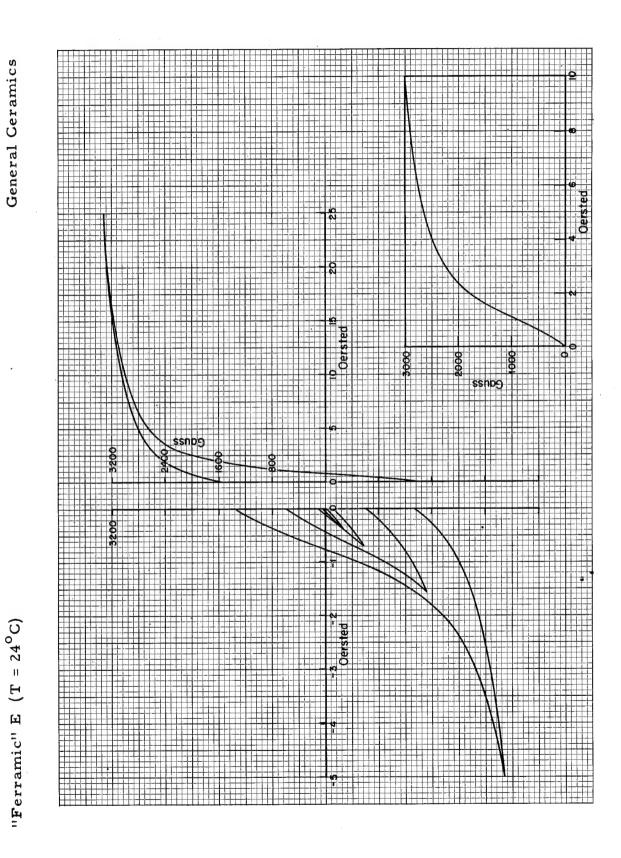
IV B 8. Commercial Ferrite Ceramics



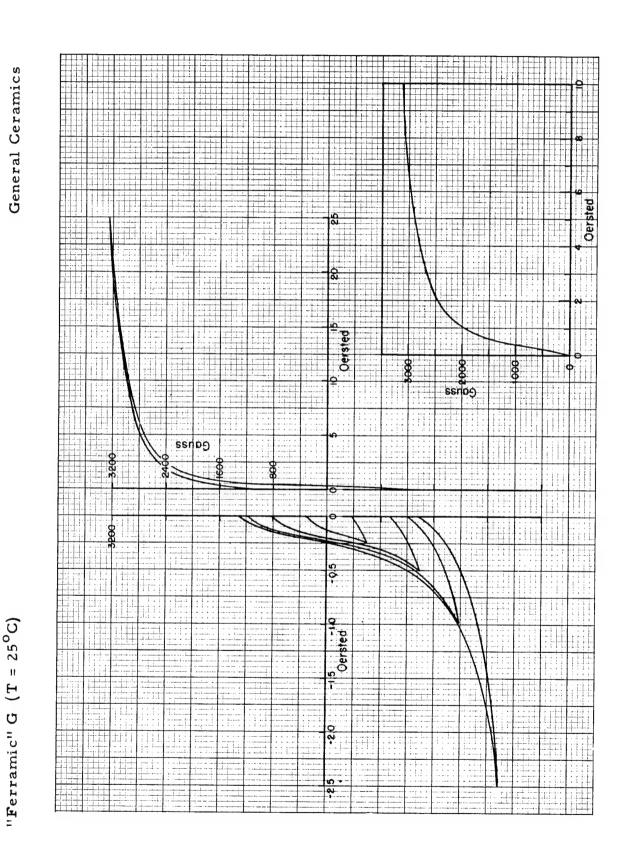
IV B 8. Commercial Ferrite Ceramics



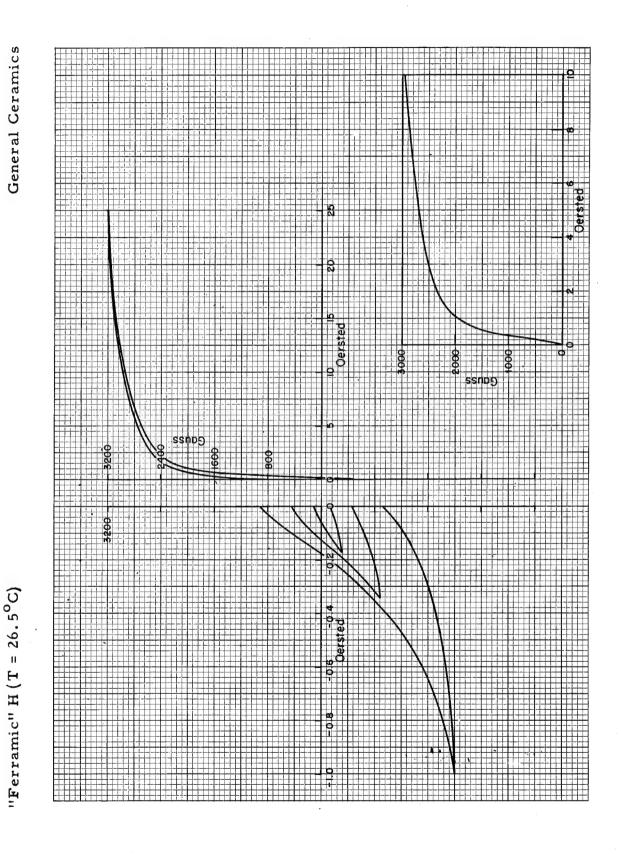
IV B 8. Commercial Ferrite Ceramics



IV B 8. Commercial Ferrite Ceramics

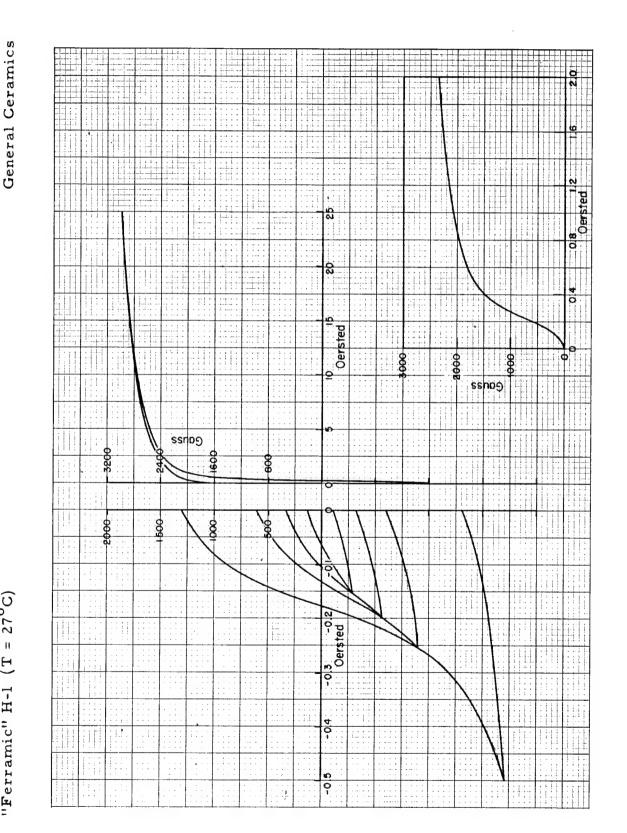


IV B 8. Commercial Ferrite Ceramics

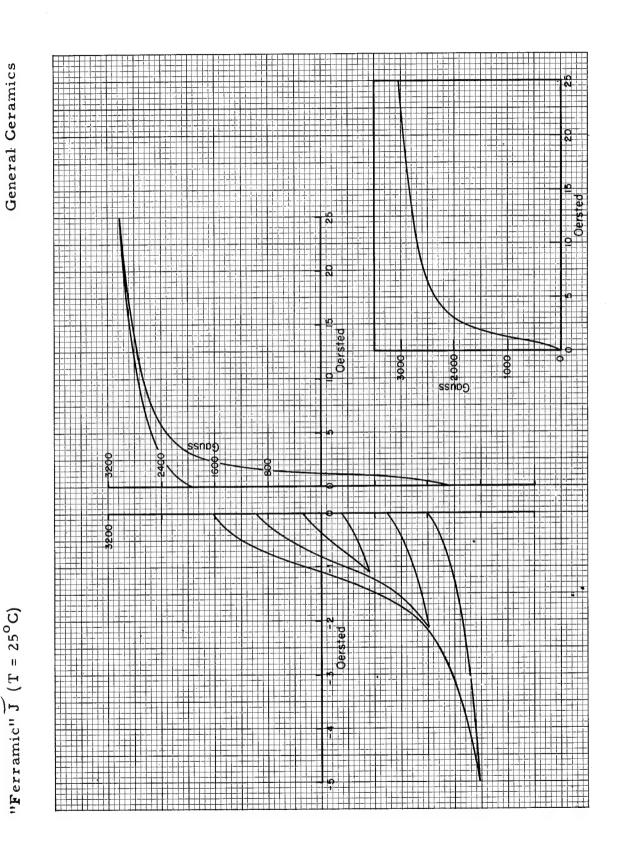


Commercial Ferrite Ceramics IVB8.

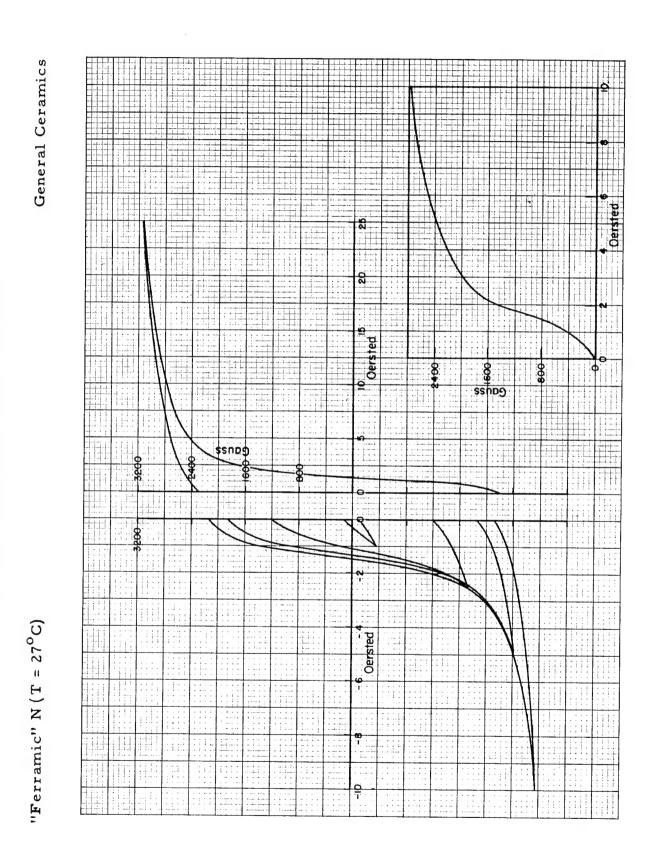
"Ferramic" H-1 $(T = 27^{\circ}C)$



IV B 8. Commercial Ferrite Ceramics

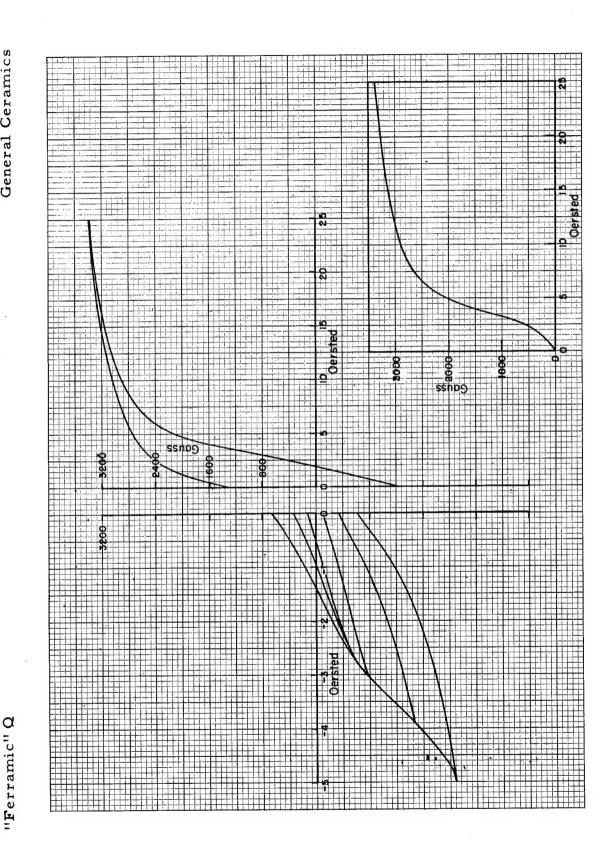


IV B 8. Commercial Ferrite Ceramics



Commercial Ferrite Ceramics IV B 8.

General Ceramics



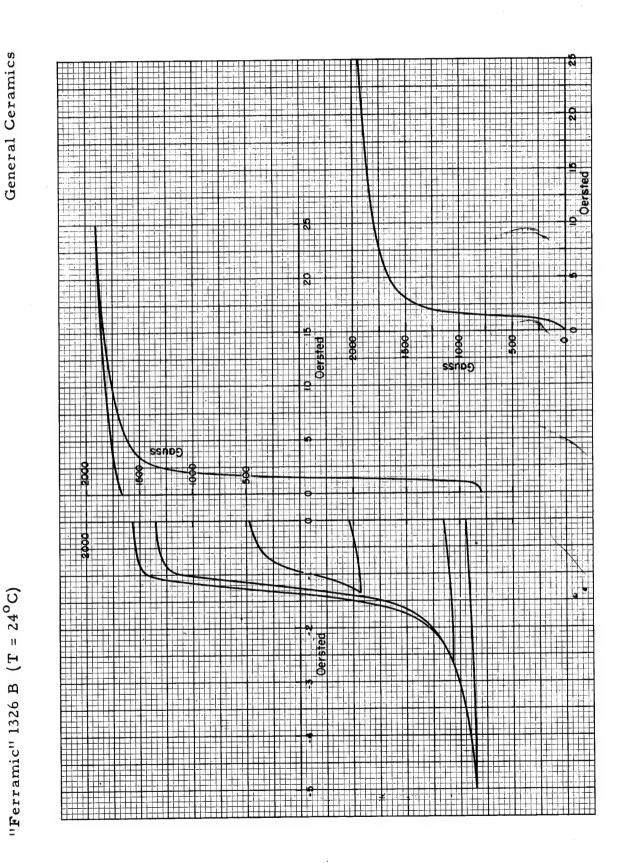
IV B 8. Commercial Ferrite Ceramics

"Ferramic" $MF 874 (T = 22^{\circ}C)$

General Ceramics

Oersted 10 Canss ssnog Oersted .

IV B 8. Commercial Ferrite Ceramics



Oersted

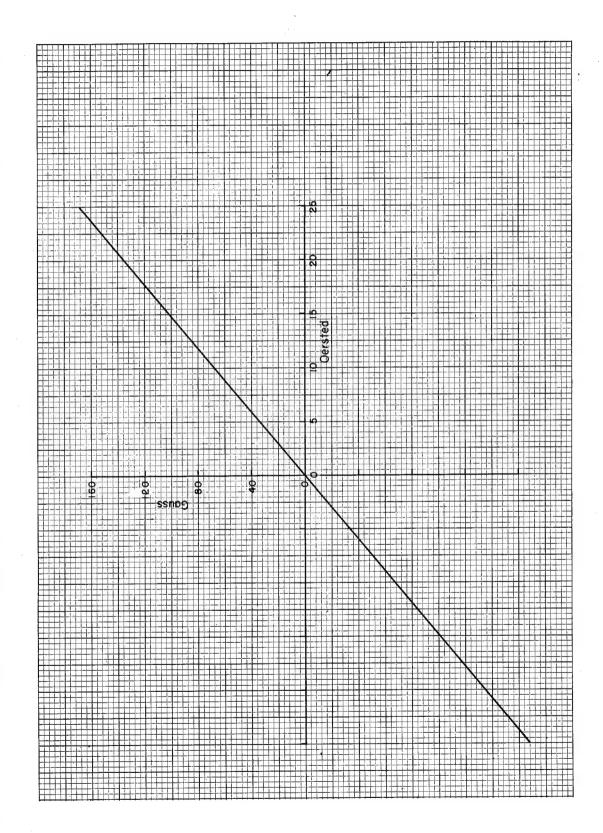
IV B 8. Commercial Ferrite Ceramics

General Ceramics 10 Cause \$SUDE "Ferramic" 1331 (T = 25° C) Oersted 2//

IV B 9. Magnetic-Plastic Mixture

"Ferrotron" Core Material, Type 119

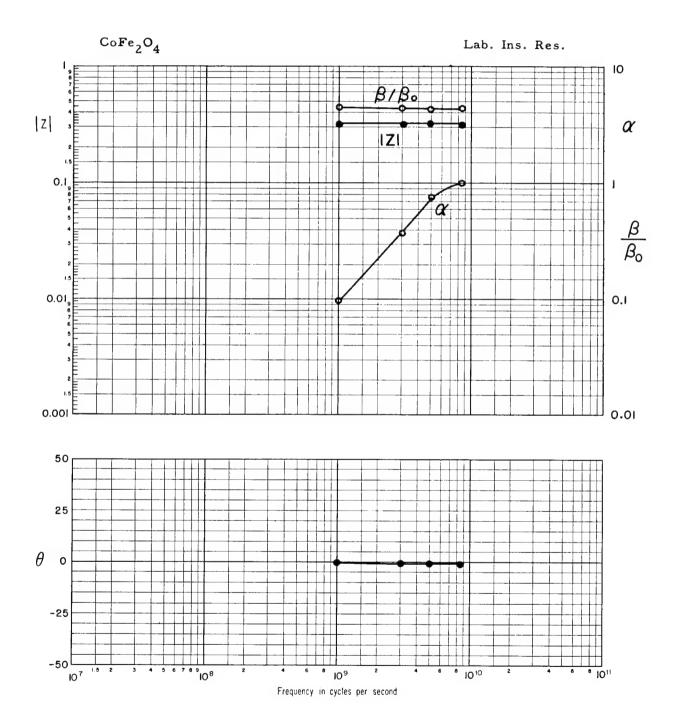
Polymer Corp.

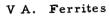


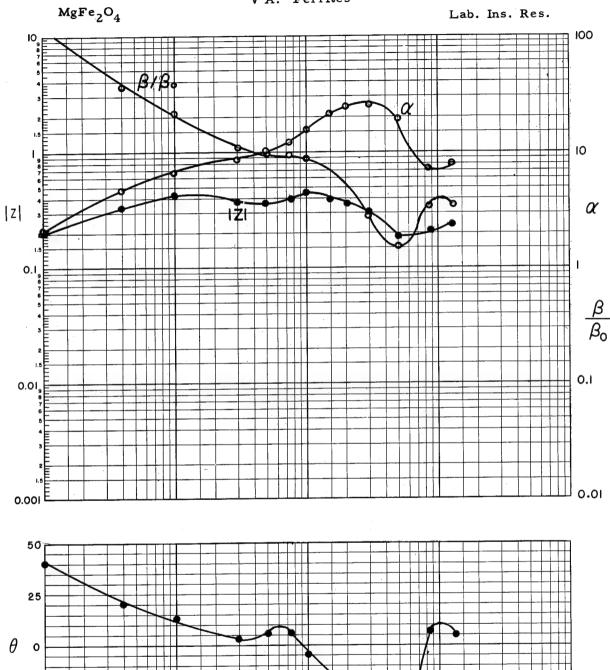
4

V. Attenuator Characteristics (Attenuation, Phase Shift, and Intrinsic Impedance)

A. Ferrites



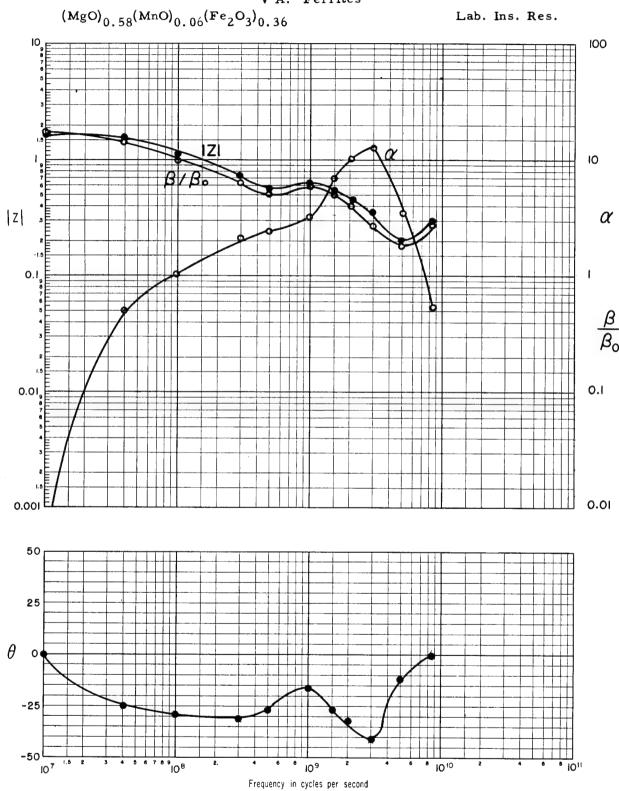


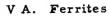


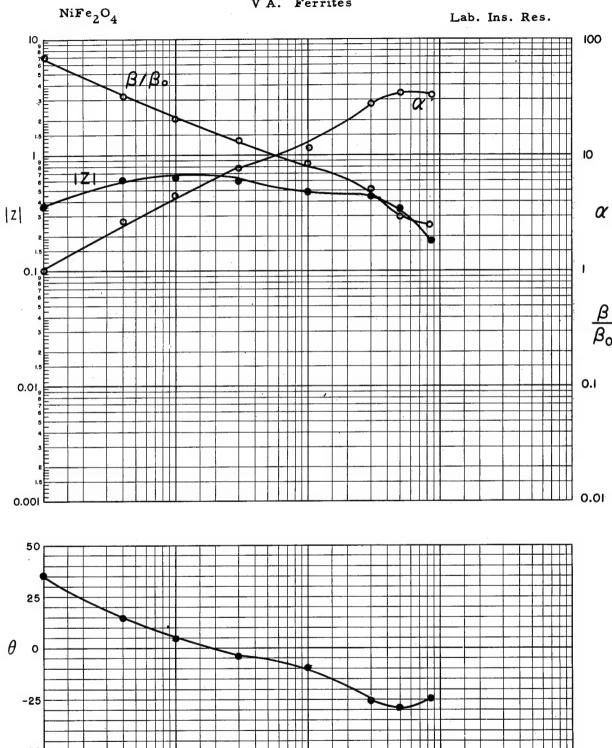
4 6 8 10⁹
Frequency in cycles per second

-25

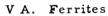
V A. Ferrites

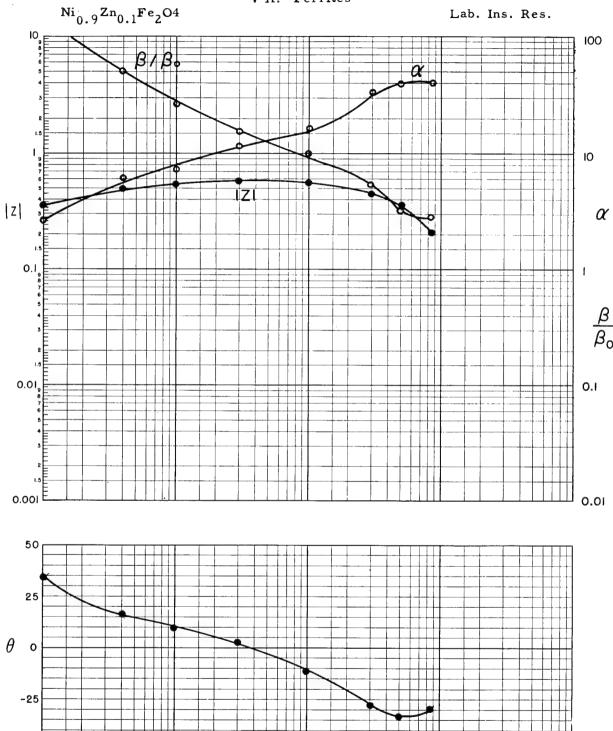






Frequency in cycles per second



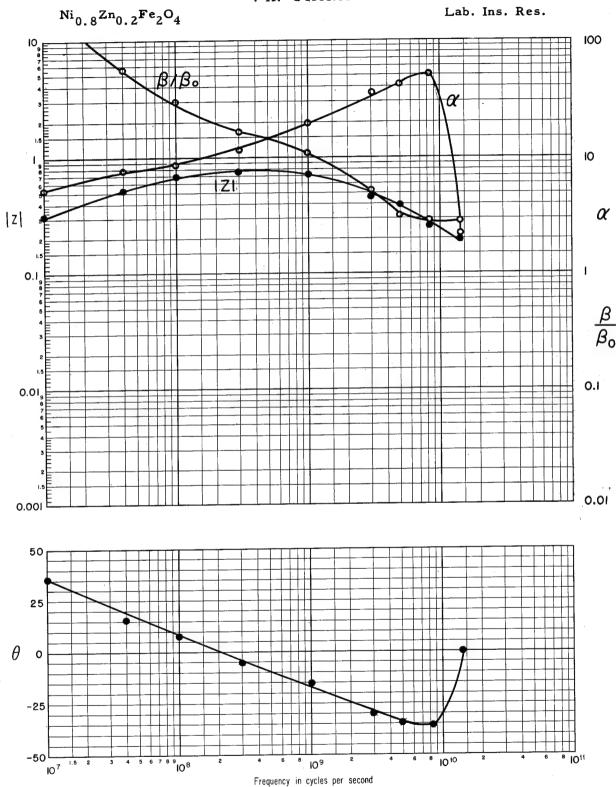


e e 10₉

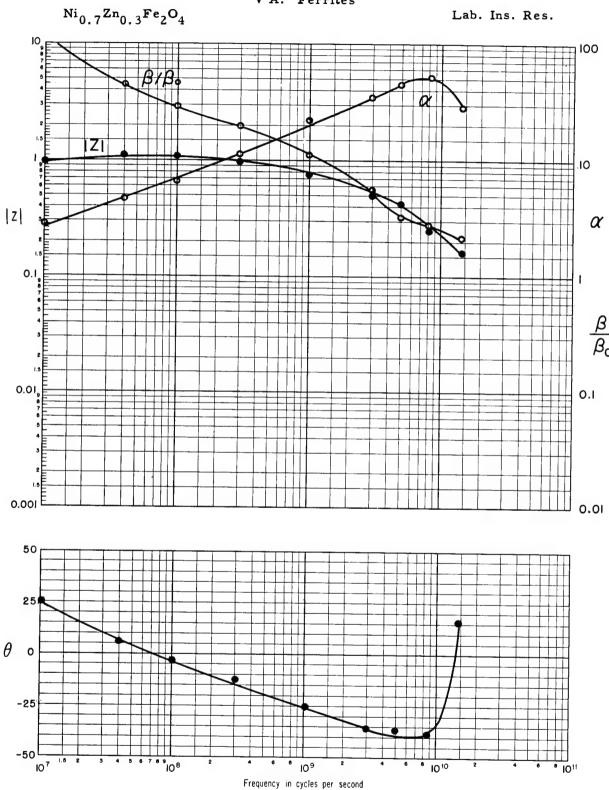
Frequency in cycles per second

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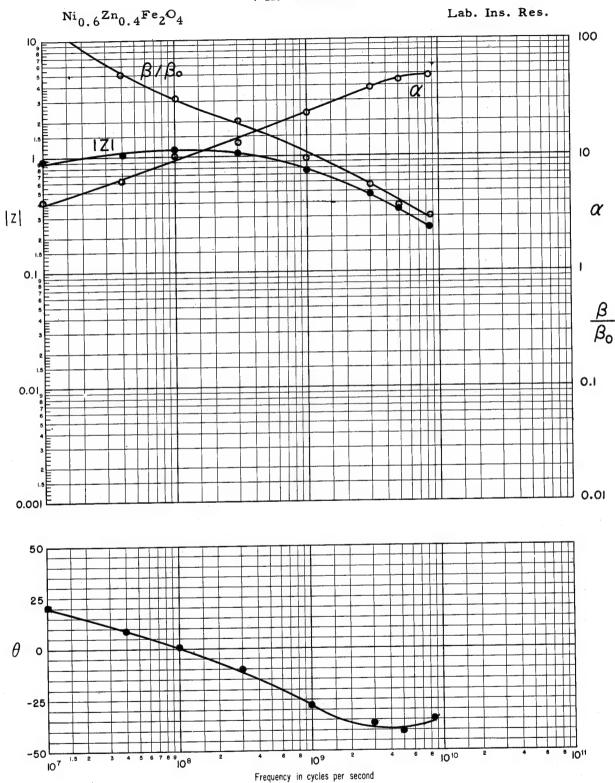
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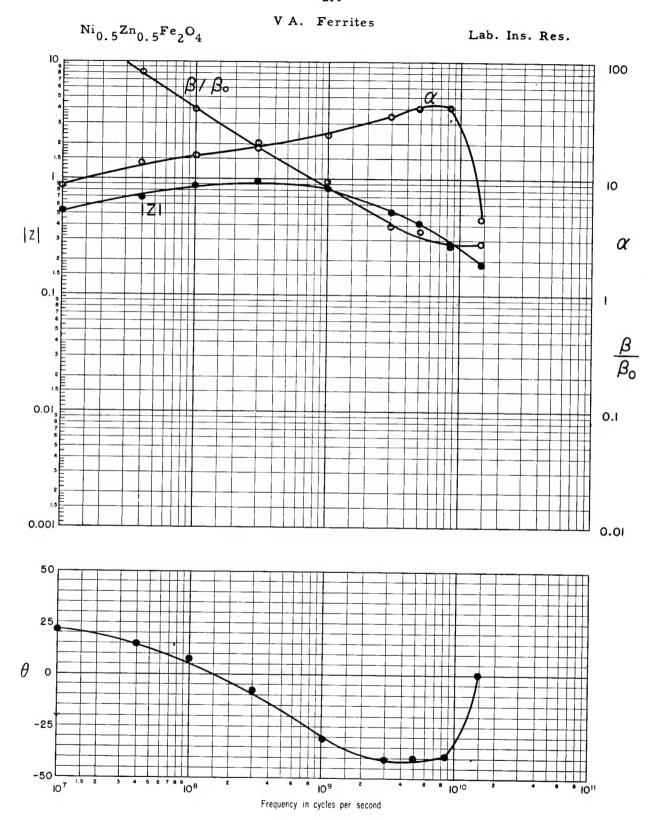


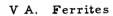
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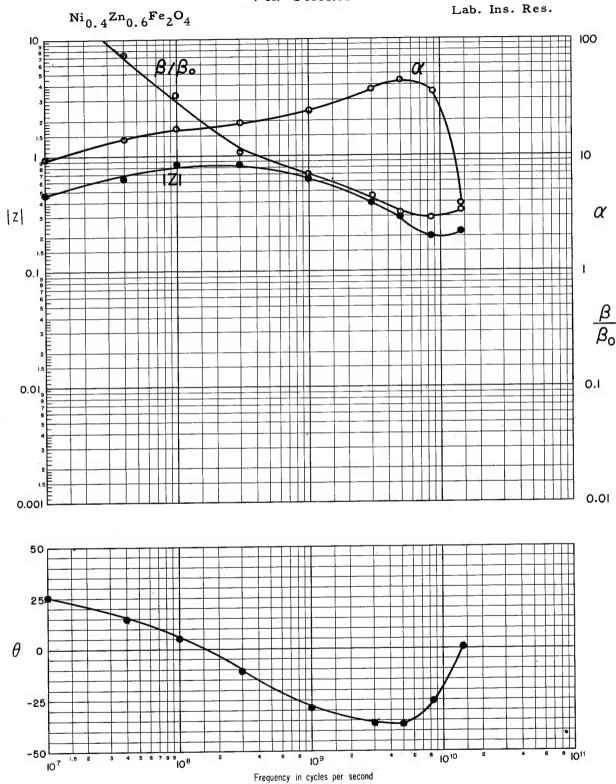


V A. Ferrites

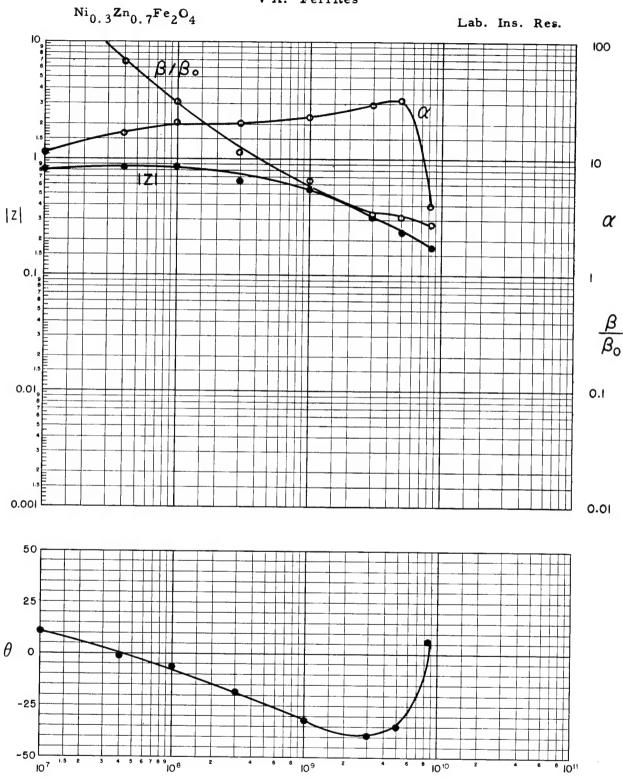






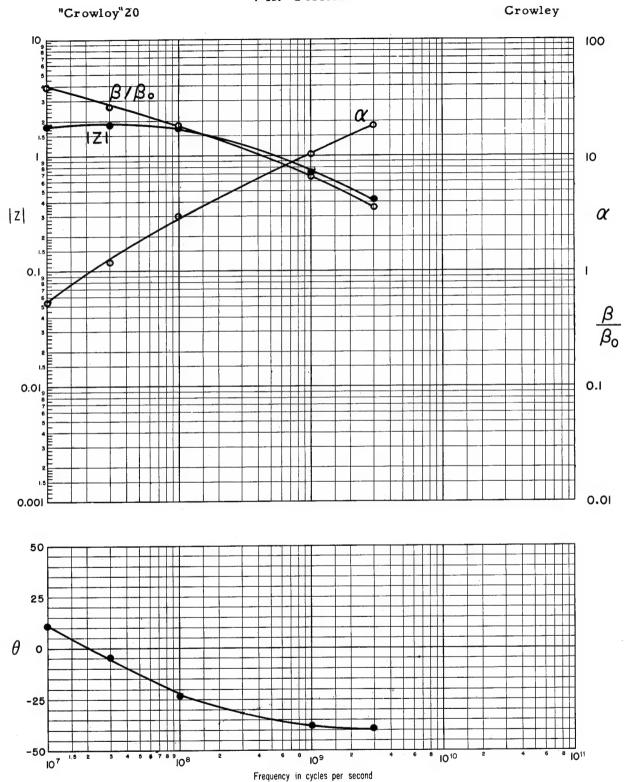


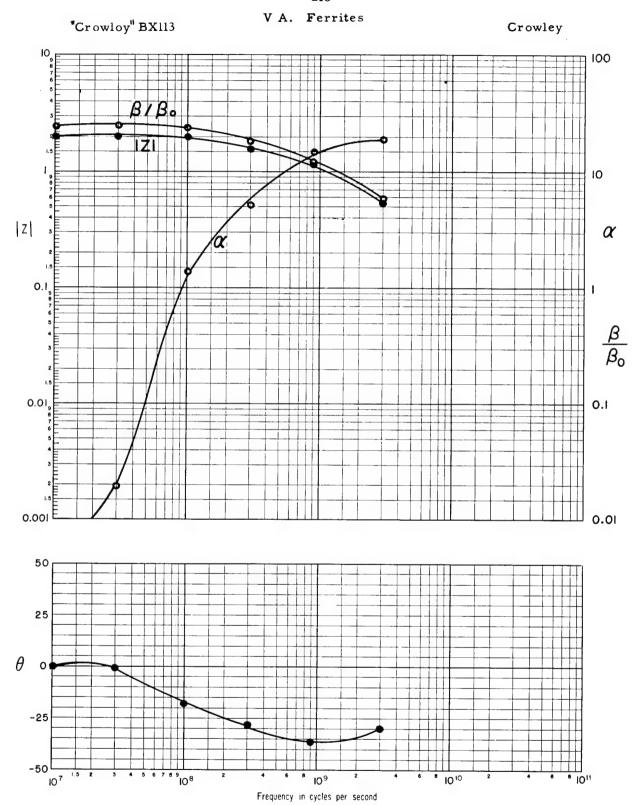
VA. Ferrites



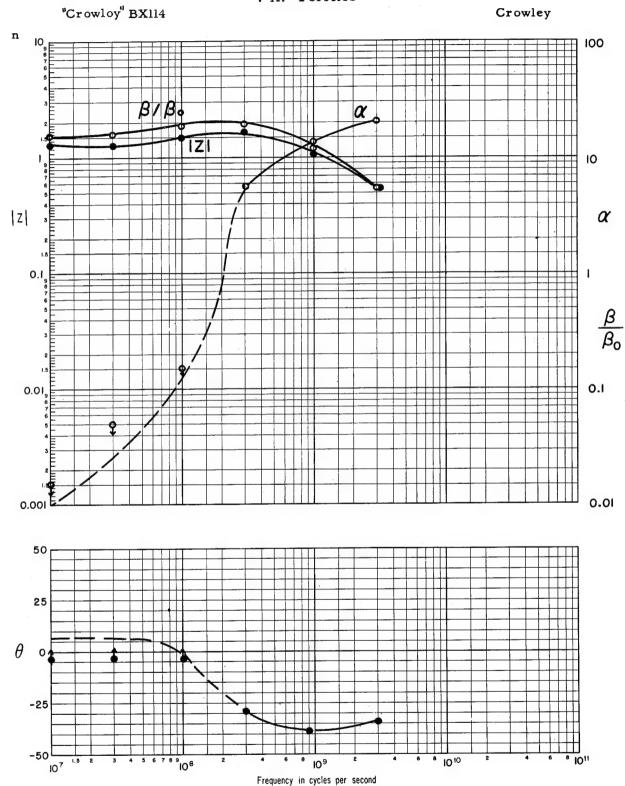
Frequency in cycles per second

V A. Ferrites

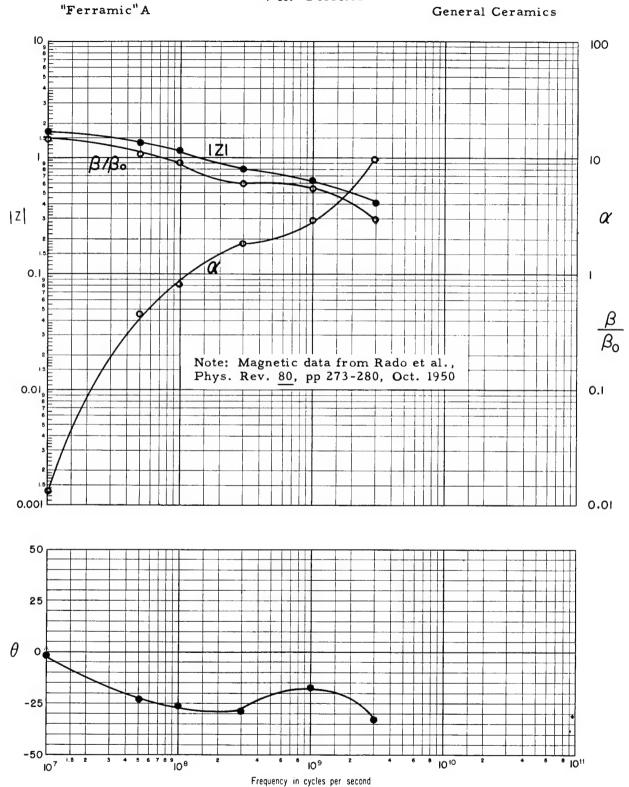


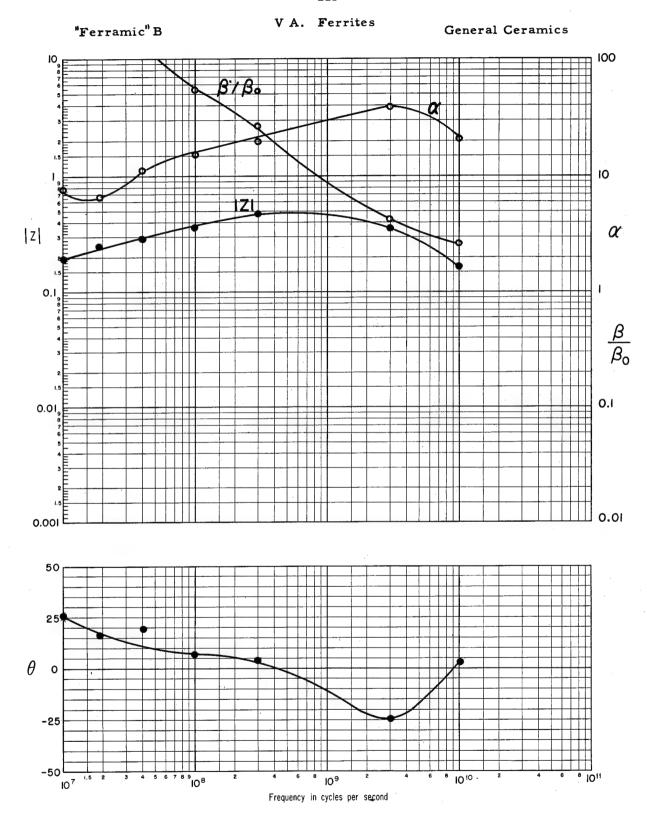


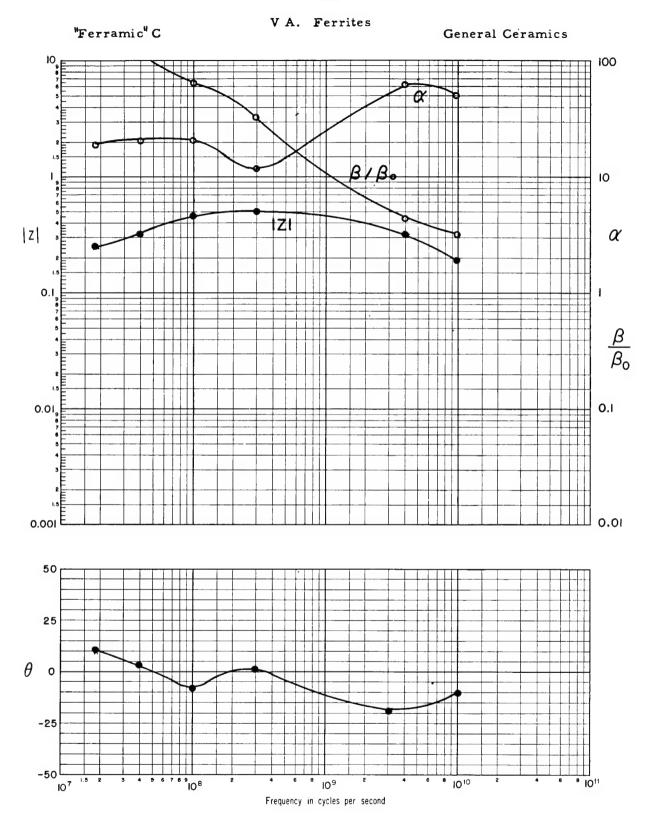
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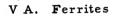


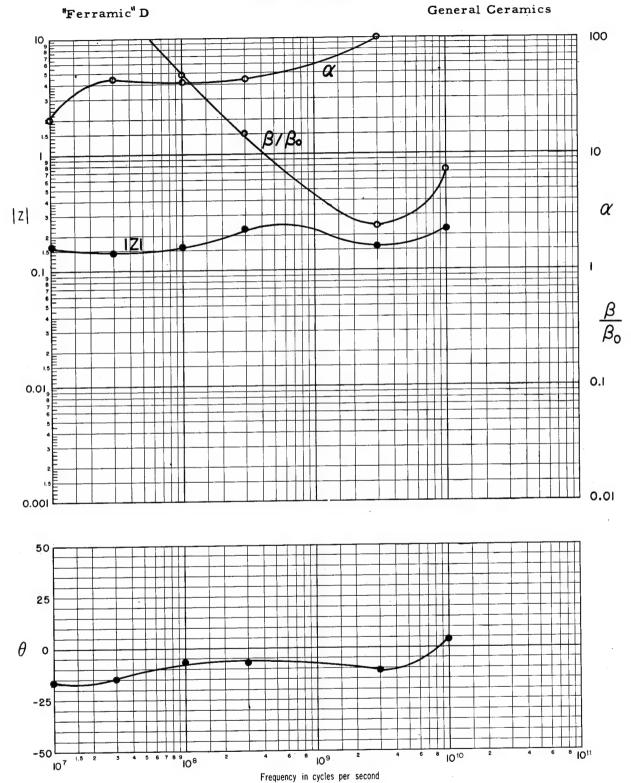
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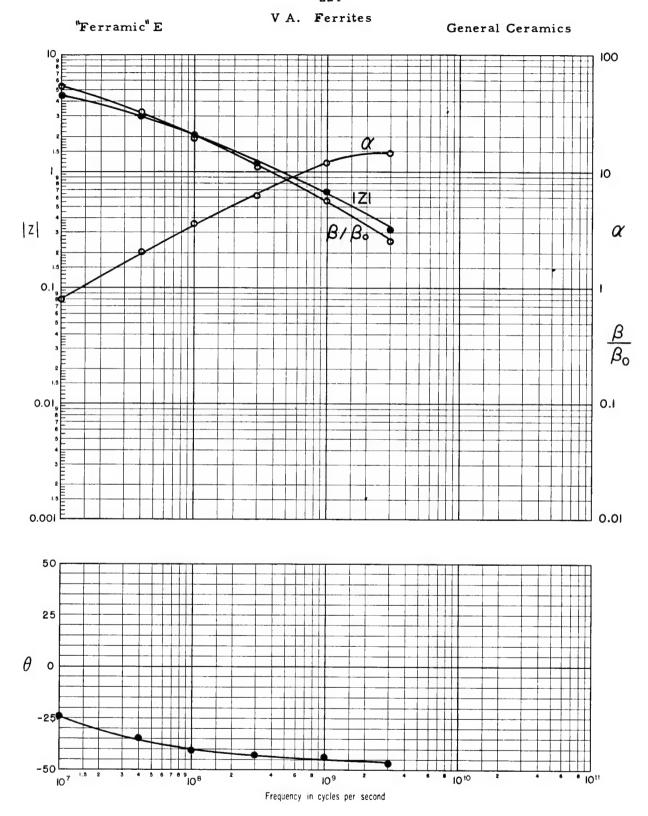


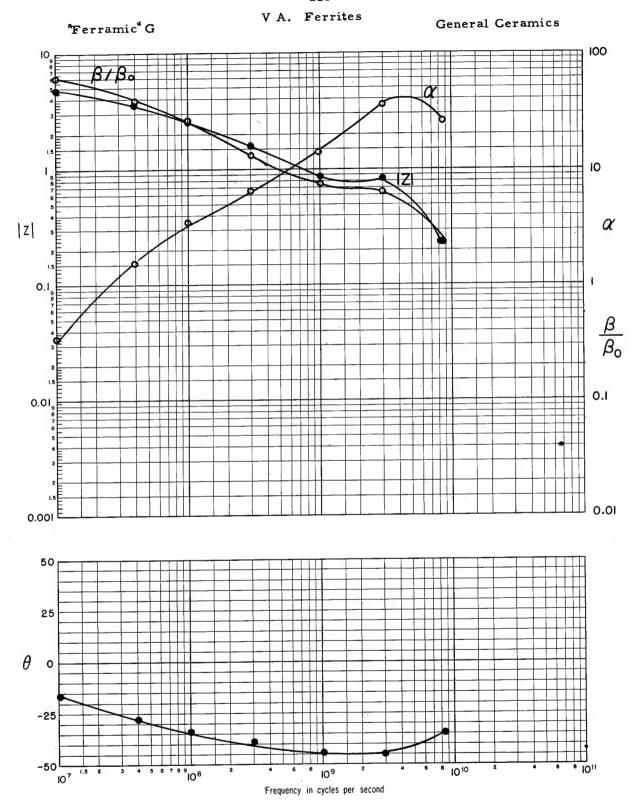




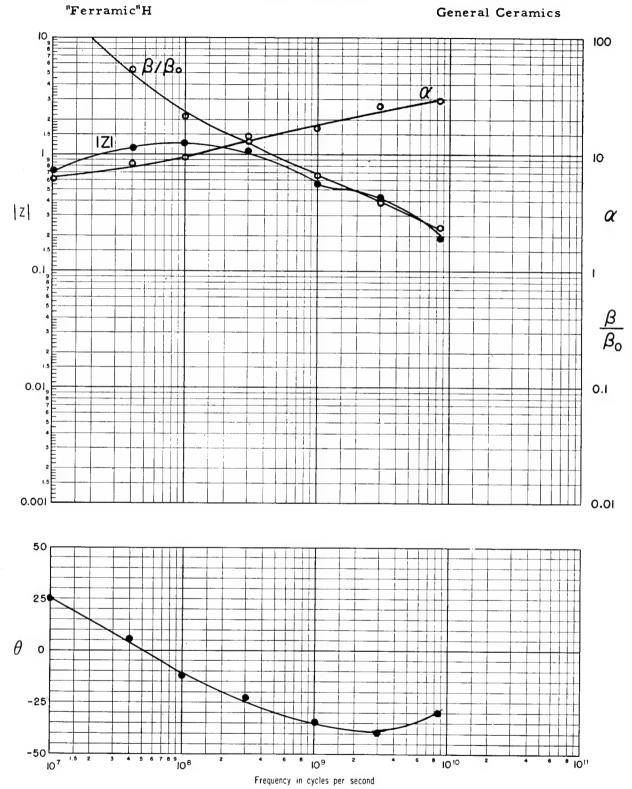


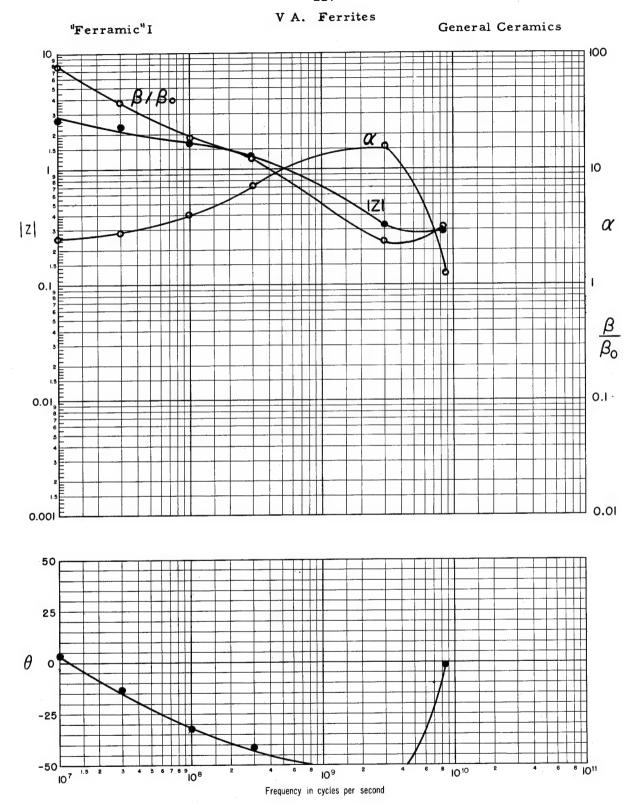




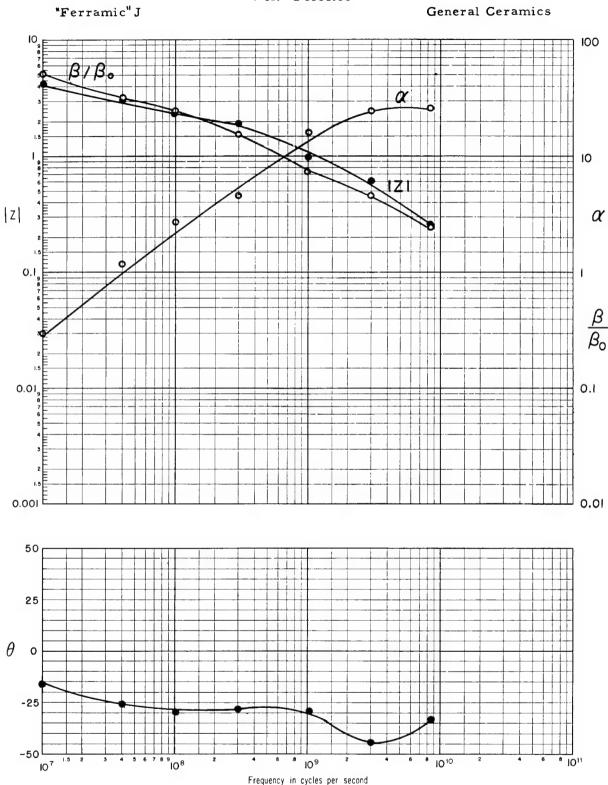


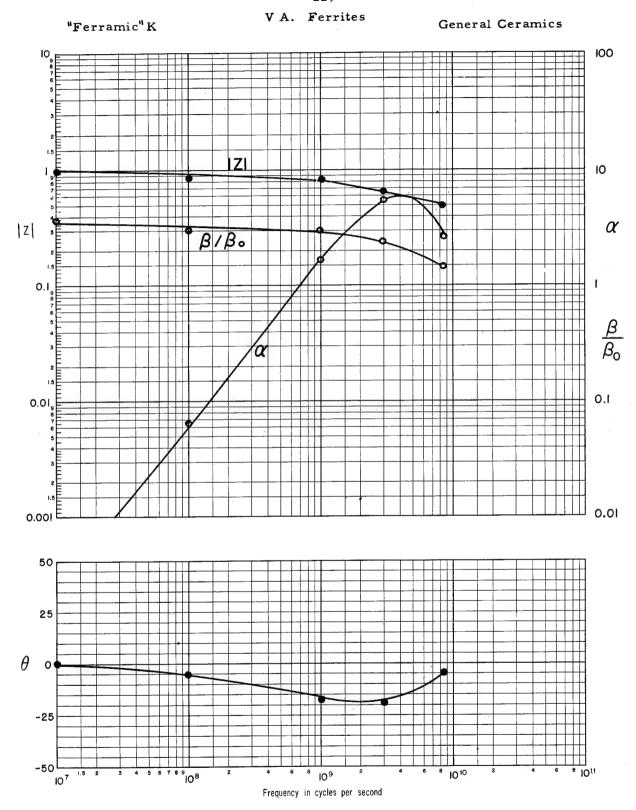
V A. Ferrites



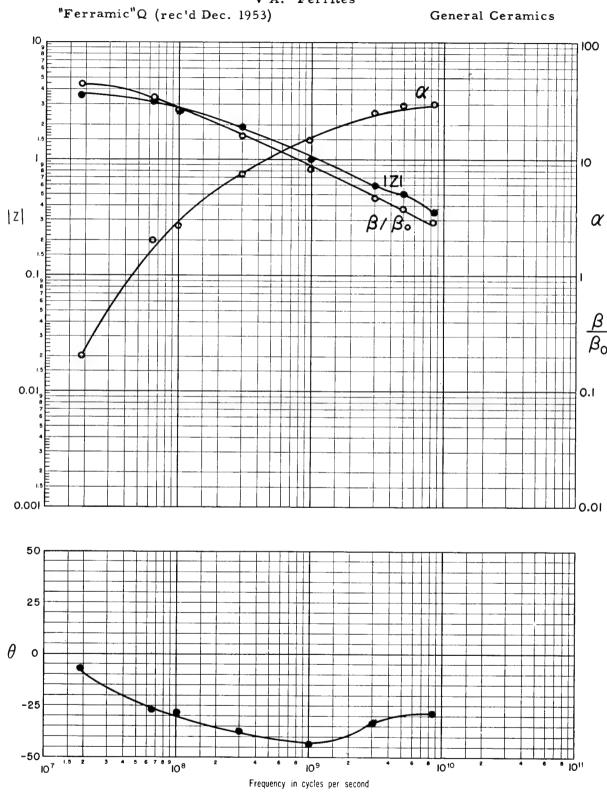


V A. Ferrites

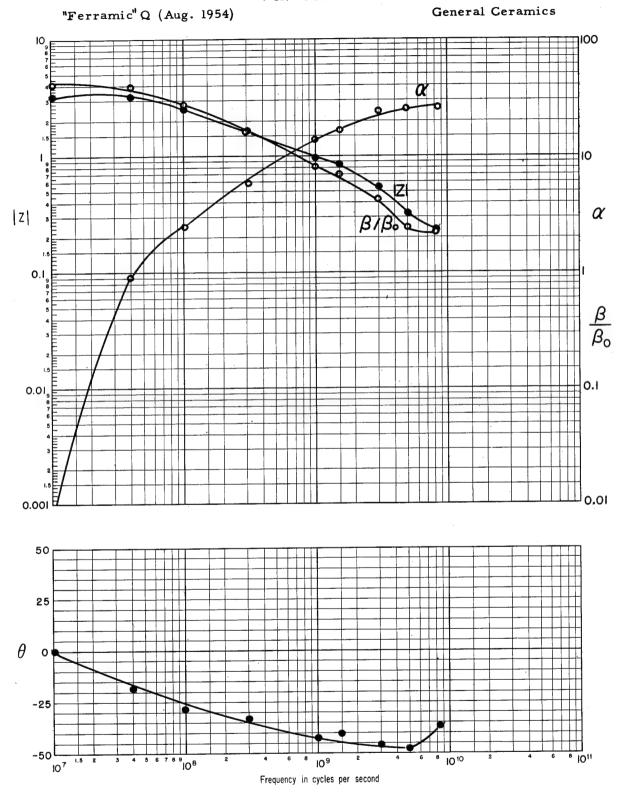


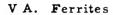


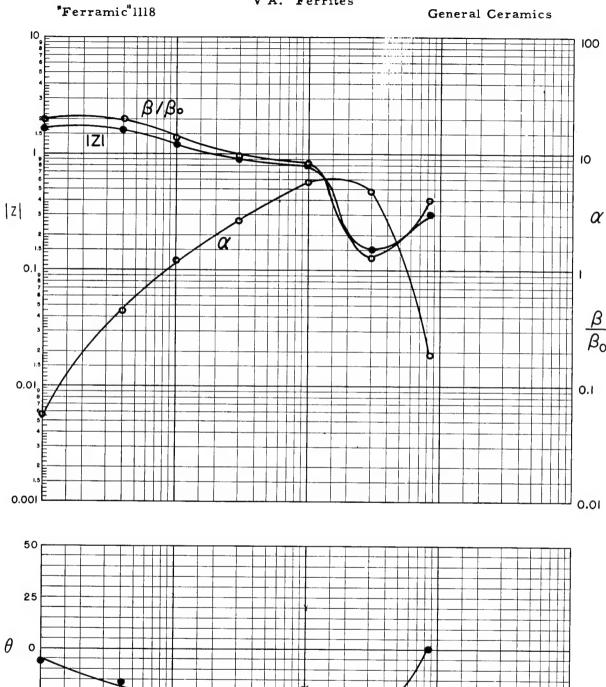
V A. Ferrites



V A. Ferrites

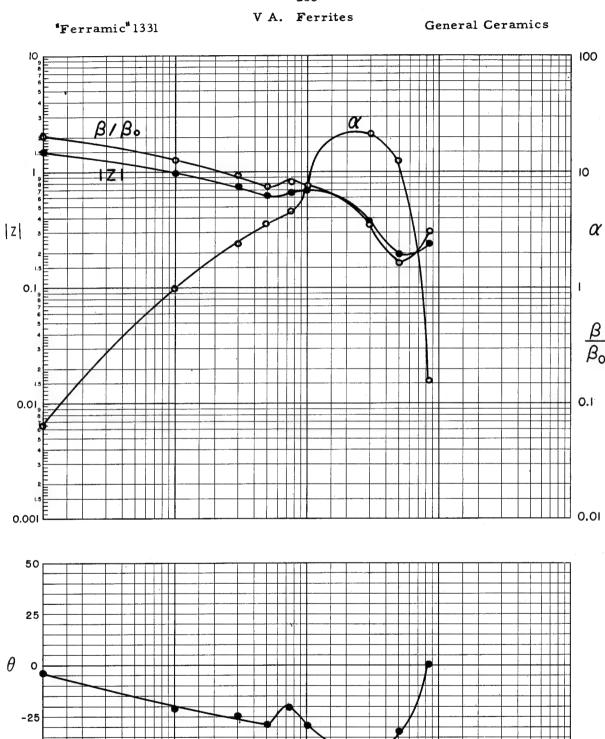






Frequency in cycles per second

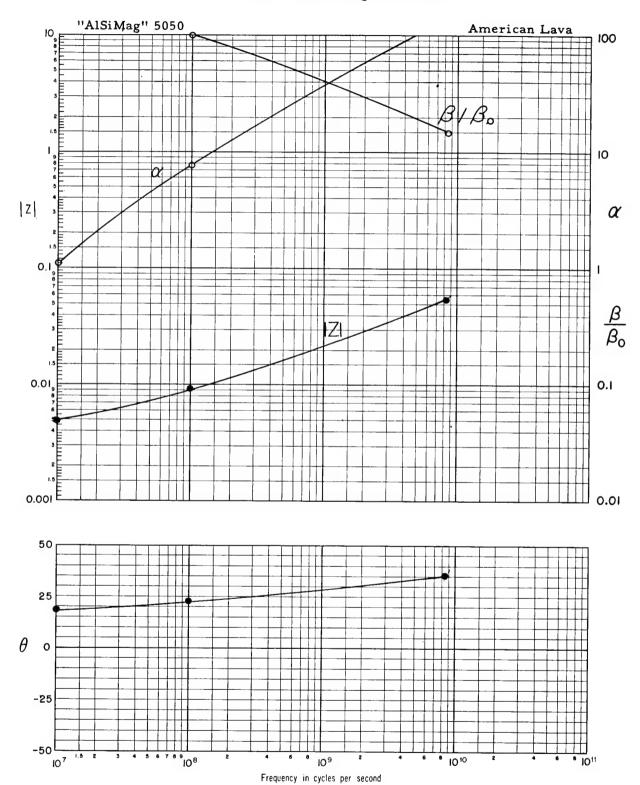
-25



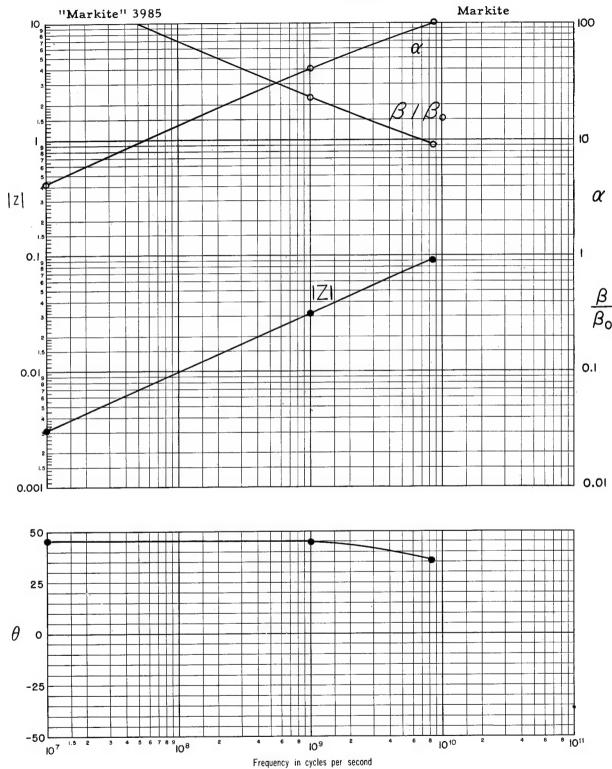
4 6 8 109
Frequency in cycles per second

⁸ 10¹⁰

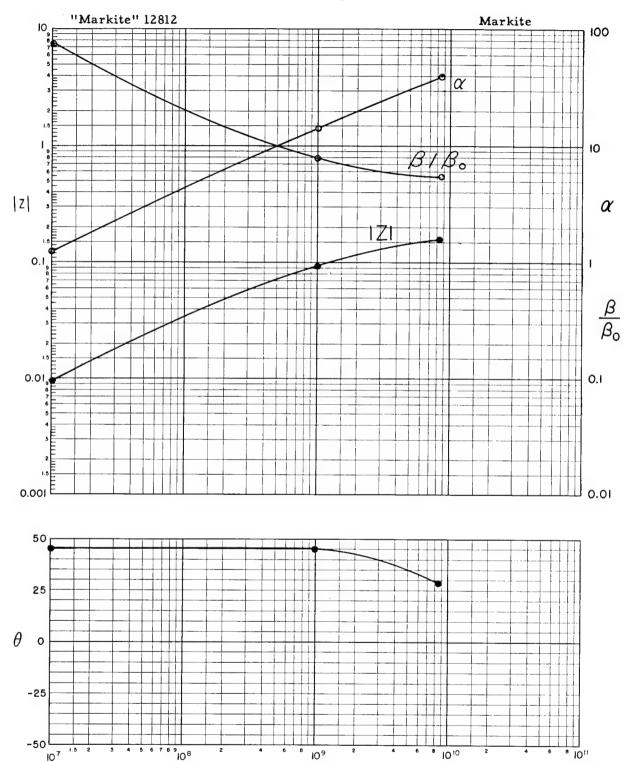
V B. Conducting Ceramics



V A. Conducting Plastics

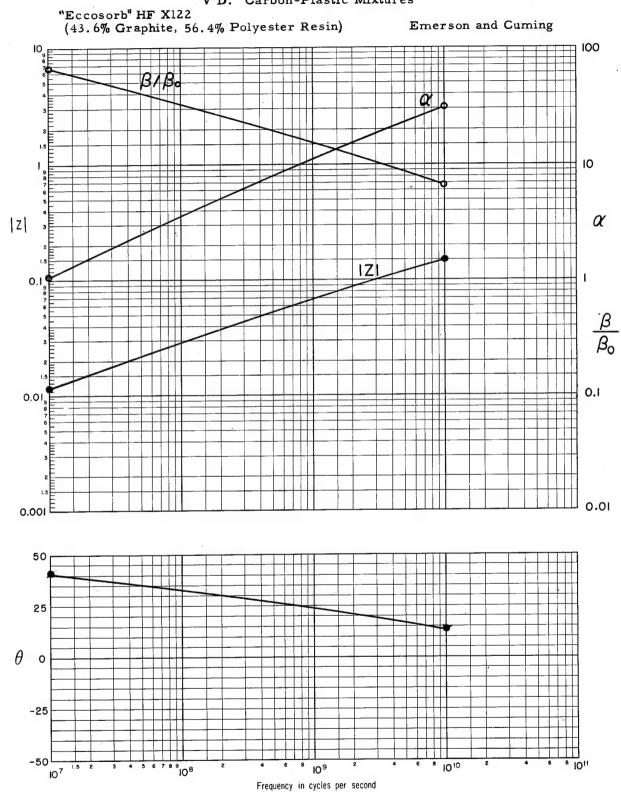


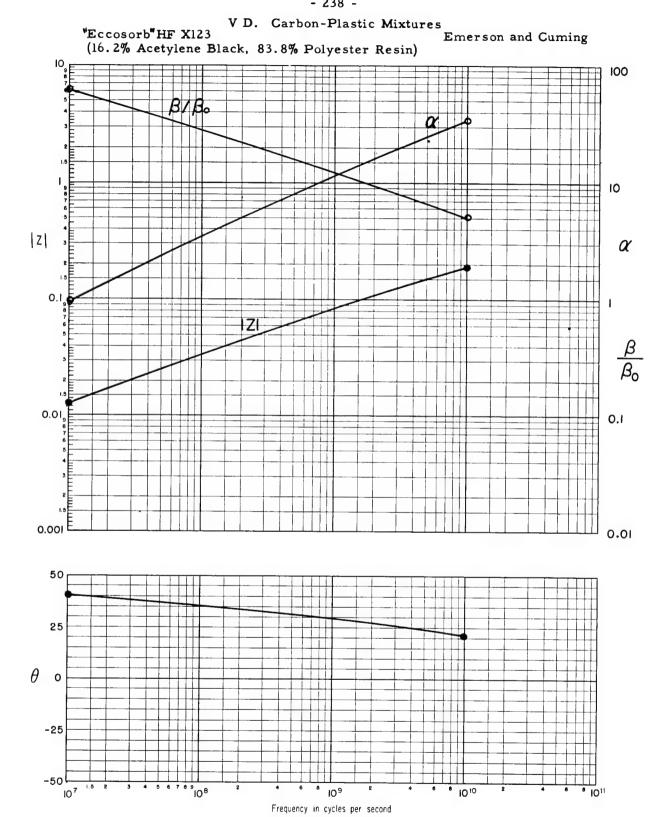
V C. Conducting Plastics



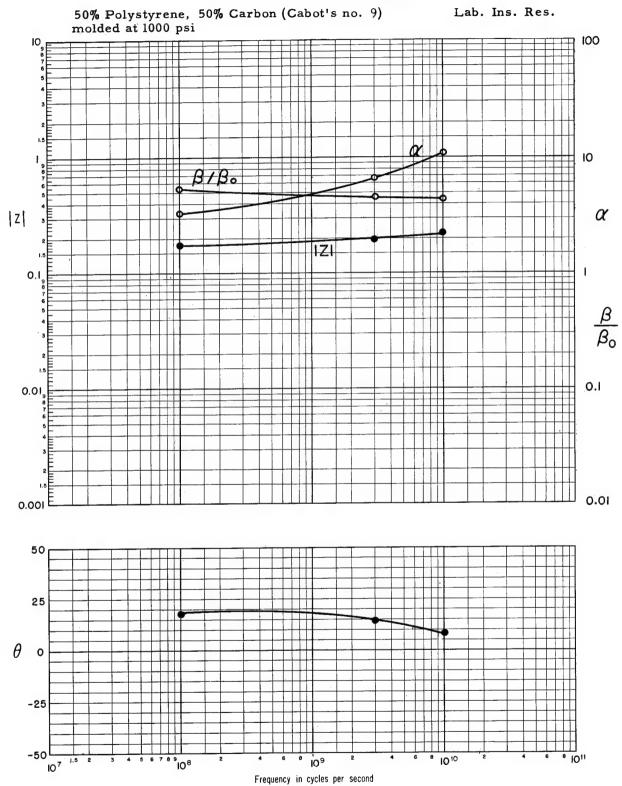
Frequency in cycles per second

- 237 -V D. Carbon-Plastic Mixtures





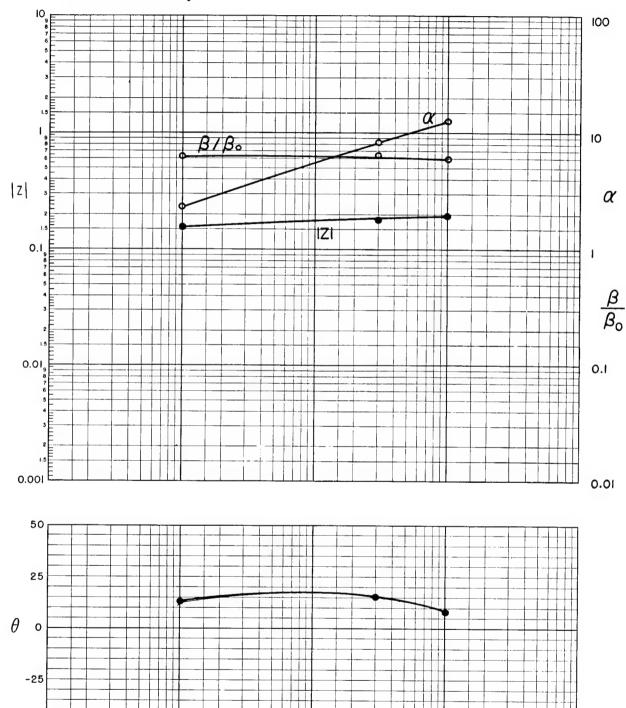
V D. Carbon-Plastic Mixtures



V D. Carbon-Plastic Mixtures

50% Polystyrene, 50% Carbon (Cabot's no. 9) molded at 10,000 psi

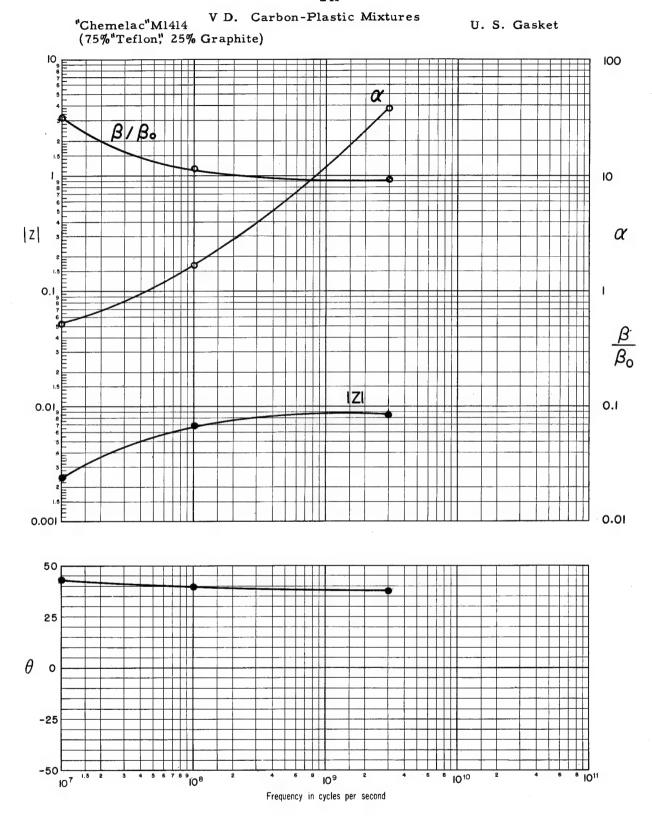
Lab. Ins. Res.



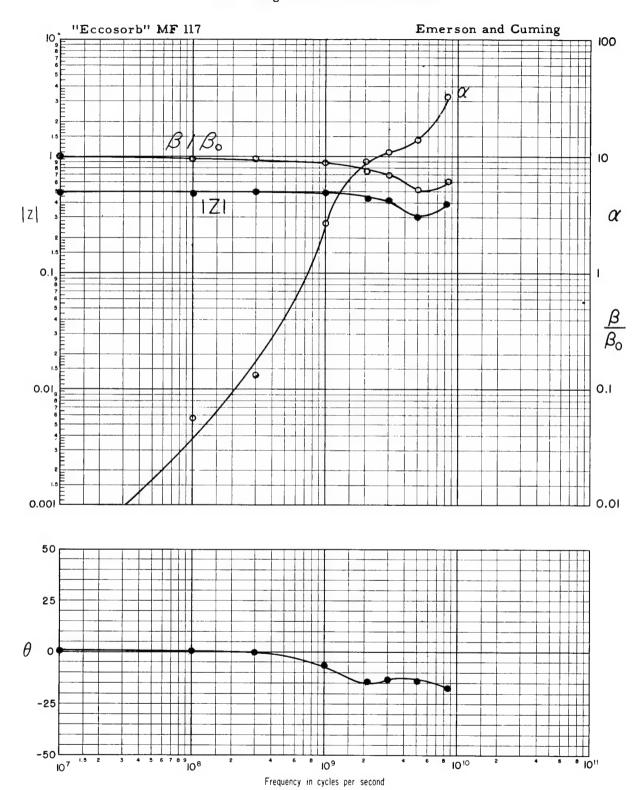
6 8 10⁹

Frequency in cycles per second

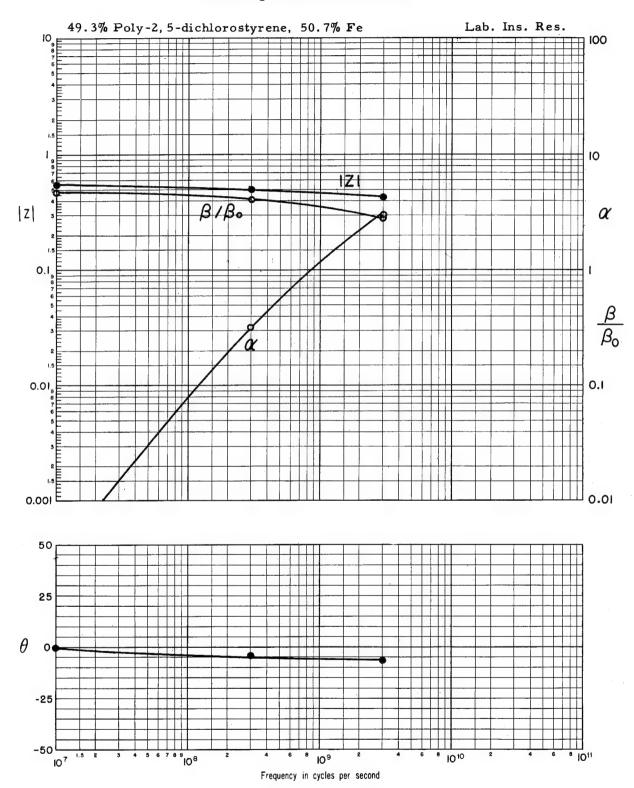
6 8 IO 10



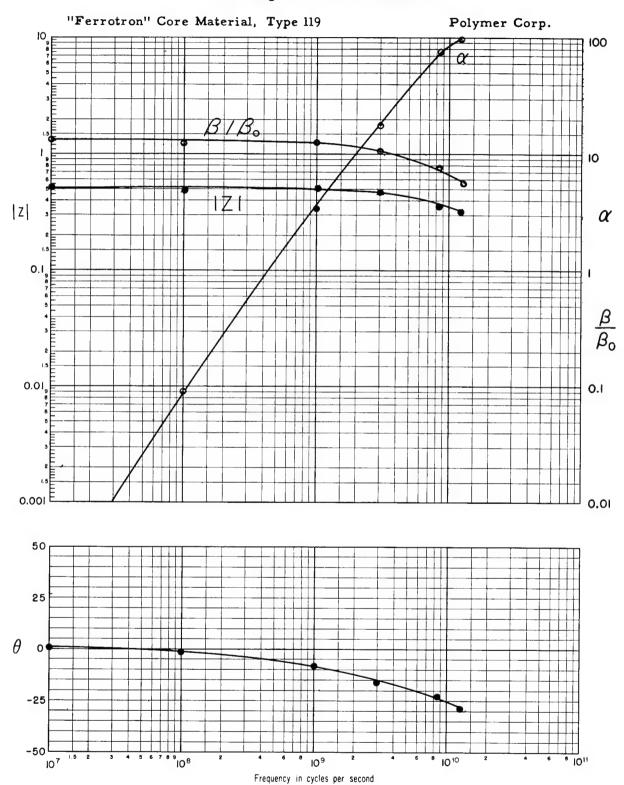
V E. Magnetic-Plastic Mixtures



V E. Magnetic-Plastic Mixtures



V E. Magnetic-Plastic Mixtures



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^{*} Add 301 to Vol. IV page numbers to find corresponding page in "Dielectric Materials and Applications," A.R. von Hippel, Editor, The Technology Press, Mass. Inst. Tech., and John Wiley and Sons, New York, 1954.

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^{*}Now The Borden Co., Chemical Div., Dept. T-56, 350 Madison Ave., New York 17, N.Y.

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- Rubber Chemical Sales, Dept. of
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 Akron 11, Ohio
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- National Research Corp., V-3
 70 Memorial Drive
 Cambridge, Mass.

^{*} Now Celanese Corp. of America, 290 Ferry Street, Newark 5, N.J.

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- Norton Co., IV-1, 6; V-3, 29, 49 50 New Bond St. Worcester 6, Mass.
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- Owens-Corning Fiberglas Corp., IV-11, 16, 22, 47, 48; V-6, 8, 13 Research and Development Labs. Newark, O.
- Pennsylvania Industrial
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- Phillips Petroleum Co., V-19 Chemical Products Dept. Bartlesville, Okla.
- Phillips Chemical Co., V-10
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- Pittsburgh Corning Corp., IV-11; V-13,19 Dept. TR, One Gateway Center Pittsburgh 22, Pa.
- Plaskon Div., IV-22, 23, 47, 49, 123; V-112, 113 Allied Chemical and Dye Corp., Dept. R-2 Toledo, O.
- Plastic Metals, Div. of National U.S. Radiator Corp., IV-43,44 123 Bridge St. Johnstown, Pa.

- Plax Corp., IV-35 P.O. Box 1019 Hartford 1, Conn.
- Polaroid Corp., IV-35, 37, 40; V-11 741 Main St. Cambridge, Mass.
- Polymer Corp. of Pennsylvania, V-17,18,205,244 2140 Fairmount Ave. Reading, Pa.
- Procter and Gamble Co., IV-60 Ivorydale Cincinnati 1, O.
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- Raytheon Mfg. Co., V-3 90 Willow St. Waltham, Mass.
- Resinous Products Div.
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- Rex Corp., IV-40; V-11,105 Hayward Rd. West Acton, Mass.
- Rezolin, Inc., IV-19 5736 West 96th St. Los Angeles 45, Calif.
- Robertson, H.H., Co., IV-48,123; V-12,19 2400 Farmers Bank Bldg. Pittsburgh 22, Pa.
- Rogers Paper Mfg. Co., IV-60 Manchester, Conn.
- Rohm and Haas Co., IV-30, 34, 48, 62, 122; V-12, 111 712 Locust St. Philadelphia 5, Pa.
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- Shell Chemical Corp., IV-50; V-16, 116-125 Resins and Plastics Dept. 50 West 50th St. New York 20, N.Y.
- Shell Devel. Co., IV-46-48 4560 Horton St. Emeryville 8, Calif.
- Shell Oil Co., IV-56,66
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- Socony Mobil Oil Co., Inc.,
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- Southern Alkali Corp., IV-48 Barberton, O.
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